

**SERVICE FILE
DO NOT REMOVE**

**320
DUAL CHANNEL
DC AMPLIFIER
RECORDER**

**SPECIAL MARKED
COPY**

OPERATING AND SERVICE MANUAL

HEWLETT
PACKARD  SANBORN
DIVISION

IM-320-2

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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OPERATING AND SERVICE MANUAL

**320
DUAL CHANNEL
DC AMPLIFIER
RECORDER**

INSTRUCTION MANUAL
DUAL CHANNEL DC AMPLIFIER RECORDER
MODEL 320



SANBORN COMPANY
WALTHAM 54, MASSACHUSETTS

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SANBORN DIVISION

MANUAL CHANGES

MODEL 320, 320R, 320T, 320TR

320TX, 320X, 320XR

Dual Channel Recorder

(MANUAL TITLE)

MANUAL PREFIXED: IM-320-2

MAKE ALL CHANGES IN THIS MANUAL ACCORDING TO THE ERRATA BELOW. ALSO CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT CR/PCO NUMBER AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

CR/PCO NUMBER	MAKE MANUAL CHANGES	CR/PCO NUMBER	MAKE MANUAL CHANGES
ALL	ERRATA	CR14017	CHANGE 4
CR11435	CHANGE 1	CR14281	CHANGE 5
ALL	CHANGE 2	CR14320	CHANGE 6
CR11908	CHANGE 3	CR14378	CHANGE 7

Δ NEW OR REVISED ITEM

ERRATA:

Page 2, Paragraph 2,

Under SENSITIVITY change smooth gain control data to read "a smooth gain control permits adjustment of range from 2-1/2 to 1."

Page 3, Paragraph 2,

Under CALIBRATION change "10 millivolts $\pm 1\%$ " to read "10 millivolts $\pm 2\%$ ".

Add the following identification data to the blank side of the page following page 4:

UNIT IDENTIFICATION:

Model 320R is a rack-mounted Model 320 Recorder.

Model 320T, 320TR is a medical version of the Model 320 with paper speeds of 2.5, 5, 25, and 50 mm/sec. Model 320TR is a rack-mounted Model 320T.

Model 320X, 320TX, 320XR have been designed to operate from 50 cycle, 115V or 230V source. A switch located at the rear of the unit provides the means of selecting the desired voltage. The X indicates that the recorder is an export version of the standard model.

May 12, 1966

DATE

EIM-320-2A

SUPPLEMENT NUMBER

MANUAL CHANGES MODEL 320 SERIES

ERRATA: (Cont.)

Rack-mounted versions are made up of the following unit and kit:

AMT.	DESCRIPTION	320R	320TR	320XR
1	Rack-mount Kit	462-231	462-231	462-231
1	as ordered Paper Take-Up	320R-300	320R-300	320R-300
1	Portable 2-Channel Recorder	320R	320T	320X
Delete:				
1	Carrying Case	320-1400	320-1400	320-1400
1	Fuse Bracket	322-107P1	322-107P1	322-107P3
1	Side Plate Spacer	320-161	320-161	320-161
1	Side Plate Spacer	320-162	320-162	320-162
1	60-cycle Nameplate	320-182	320T-104	-----
1	as ordered 50-cycle Nameplate	320-183	320T-105	320X-183
1	Cord and plug set	10G3-33MW	10G3-33MW	10G3-33MW
Add:				
1	60-cycle Nameplate	320R-102	320TR-102	-----
1	as ordered 50-cycle Nameplate	320R-103	320TR-103	-----
1	50-cycle Nameplate	-----	-----	320XR-103

Page 9, Paragraph 5, under HEAT;

add the following: Maximum stylus heat control settings should be used when recording frequencies in the middle to high frequency range of the recorder frequency response characteristics.

CHANGE 1:

Page 13, Add Paragraph,

10. REMOTE MARKER

Connector J5, at the rear of the recorder, can be used to apply an external marker signal to the Marker.

- Construct a signal cable with the phone plug supplied
- Connect the cable to J5.
- Excite the marker writing arm from any source (e.g., SPST switch) which provides a contact closure.

MANUAL CHANGES MODEL 320 SERIES

CR/PCO NUMBER	MAKE MANUAL CHANGES	CR/PCO NUMBER	MAKE MANUAL CHANGES
CR14666	CHANGE 8	CR14951	CHANGE 12
CR14776	CHANGE 9	PCO17-15076	CHANGE 13
CR14811	CHANGE 10	PCO17-15263	CHANGE 14
CR14928	CHANGE 11		

Δ NEW OR REVISED ITEM

CHANGE 2: Page 1, Paragraph 1,
Add following to GENERAL DESCRIPTION,
Sanborn Dual Channel DC Amplifier-Recorder, Model 320 and 320T,
use a printed circuit plug-in regulator board. The three models are
identified as follows:

Model 320-100-C12, 1200 cycle oscillator,
Model 320-100-C24, 1200 cycle oscillator,
Model 321-100-C10, 2400 cycle oscillator.

CHANGE 3: Page 4, Paragraph 3,
Under INPUT, change "12-terminal connector, etc" to read
"3-contact (2 contacts guarded) male connector, etc."

Page 10, Paragraph 6
Under SIGNAL CONNECTION, delete Figure 10 and reference thereto.
Change the letter designations to coincide with the 3-contact connector
as follows:

Terminal E to A
Terminal F to B
Terminal M to C (ground)
Terminals K, A, B, C, D, H, J, L, N to guard.

MANUAL CHANGES MODEL 320 SERIES

CHANGE 4: Change Parts List at the rear of the manual;
 Timer Assembly No. 152-1300B-C2P5 is changed to REED TIMER ASSEMBLY No. 14002C. The timers are interchangeable. The Model 14002C is for 1-second, 60-cycle, applications and consists of the following:

Switch Actuator Assembly	14002-60010
Arm	14002-00010
Hub	14002-20010
Rivet	47A-1
Magnet	62RC-2
Set Screw	81A-632G
Timer Mounting Bracket	154B-1305P1
Printed Board	752-417
Sync. Motor (60 rpm, 60 cy)	38B-21
Magnetic Reed Switch	62V-1
Sems	83A-6-4B

Timer Assembly No. 152-1300B-C2P6 is changed to Reed Timer Assembly No. 14002D. The parts are the same as for the 14002C except as follows:

Sync Motor (60 rpm, 50 cycle) 38B-21A

CHANGE 5: Change Schematic and Replacement Parts List at the rear of the Manual;
 Change R108 to 100K $\pm 5\%$, 1/2W, Sanborn No. 50AB-104J, Vendor Code EB(AB).
 Add NOTE 9. Resistor R108 is added in parallel with R48 to provide 2% calibration accuracy.

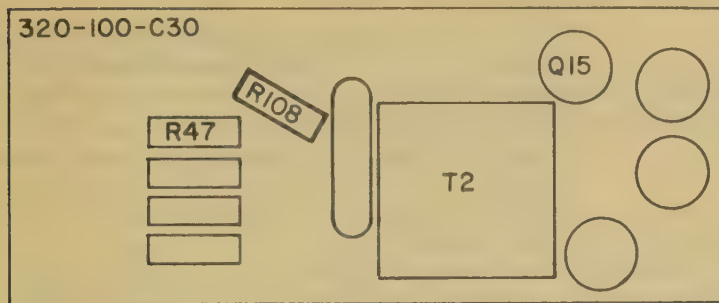
CHANGE 6: Change Schematic and Replacement Parts List at the rear of the Manual;
 Change C25 to 120 μ F, 10V, Sanborn No. 8T-8, Vendor Code 150D (SPR).

CHANGE 7: Change Schematic and Replacement Parts List;
 Change R70 and R80 to 3.3K $\pm 5\%$, 1/2W, Sanborn No. 50AB-332J, Vendor Code EB (AB).

CHANGE 8: Change Schematic and Parts List;
 C46; change to .02 μ F; Sanborn No. 8E-17, Vendor ID-203 Centralab
 C46 is to be located between the base and collector of Q21.

CHANGE 9: Change Parts List;
 Printed circuit assembly 320-100-C30 is revised to show the location of R108. See figure.

MANUAL CHANGES MODEL 320 SERIES



CHANGE 10:

Change Schematic and Parts List;

Q1; change to 2N1307 selected; Sanborn No. 16T-58B; Vendor SAN.
Q7; change to 2N1307; Sanborn No. 16T-58; Vendor 2N1307 (RCA).
Q3, Q10, Q11, Q12; change to 2N3393; Sanborn No. 16T-78;
Vendor 2N3393 (GE).
C51; capacitor is deleted.

Page 34, Paragraph 14 and Figure 11 in the Parts List;

Add the following information;

CHANGES TO GALVANOMETER INSERT

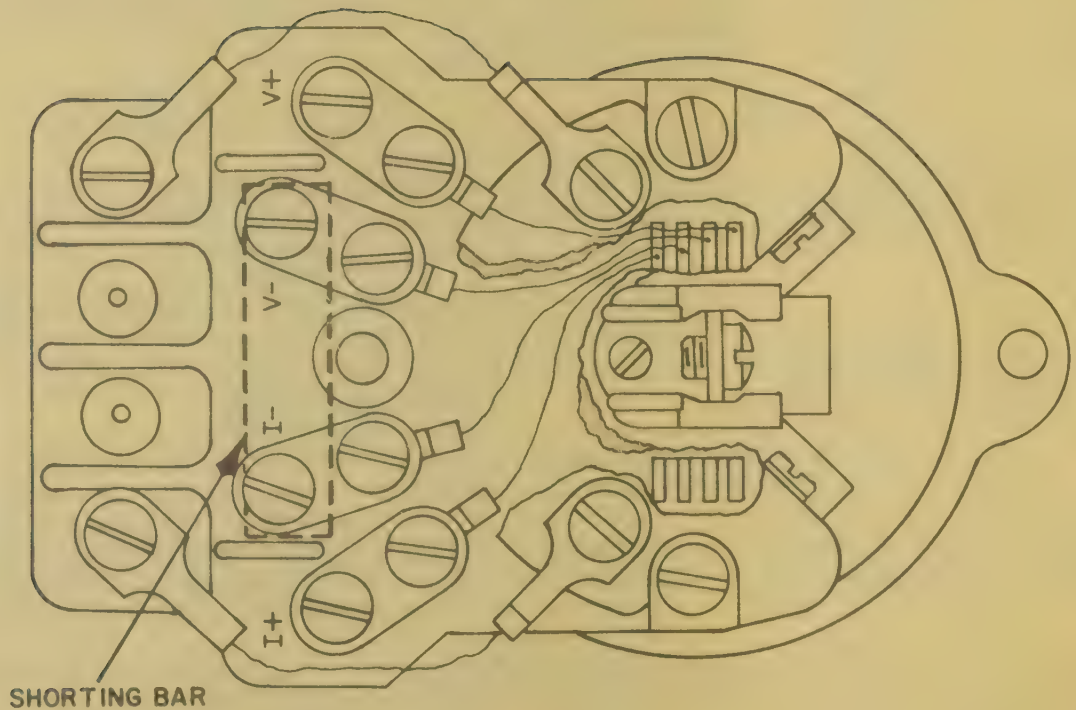
1. Galvanometers Models 607, 608, 608D formerly used Galvanometer INSERT Model 606. They will now use Galvanometer INSERT Model 606B as a direct replacement.
2. When Galvanometer INSERT model 606B is installed the GALVANOMETER Model number will change as follows:
607 will become 607B
608 will become 608B
608D will become 608E
3. Electrically Galvanometer INSERT 606 and 606B are the same.
4. Physically INSERT 606 has two coils on the coil frame. One lead of each coil is connected together at the coil frame. Three leads are brought up to the three terminals at the top of the coil frame. These terminals are then connected to the +, CT, -, terminals on the cap. The fourth terminal on the cap is not used.
5. INSERT 606B coils are not connected at the coil frame. Four leads are brought up to the four terminals at the top of the coil frame. These terminals are then connected to I+, I-, V-, V+ terminals on the cap. A shorting bar is placed from I- to V- thus making it electrically the same as the Model 606.
6. The Model 606B without the shorting bar becomes Galvanometer INSERT Model 606A. The 606A will be used in latest Sanborn Recorders of the 350 Series. The required shorting of terminals I-, V- will take place in the Driver Amplifier.

NOTE: INSERT 606A (without shorting bar) cannot be used in a system using 606 or 606B INSERTS.

MANUAL CHANGES MODEL 320 SERIES

CHANGE 10: (Cont.)

7. For a short time the old style CAP with four terminals marked +, CT, -, (one unused) will be placed in service. The four ends of the two coils will be brought up to the four terminals at the top of the coil frame and then connected to the +, CT, -, (unmarked) terminals. A shorting bar will be across CT and -. This will then be a 606B INSERT.



MANUAL CHANGES MODEL 320 SERIES

- CHANGE 11: Change Schematic and Parts List;
C45; capacitor deleted.
R109 resistor, 10Ω , $\pm 5\%$, $1/2W$; Sanborn No. 50AB-100J; Vendor EB(AB).
R109 added between J5-TIP (Remote Marker) and the open side of S5 on the timer assembly.
- CHANGE 12: Change Schematic and Parts List;
R74; Change to $120K$, $\pm 5\%$; Sanborn No. 50AB-124J; Vendor EB(AB).
R88;; change to $10K$, $\pm 5\%$; Sanborn No. 50AB-103J; Vendor EB(AB).
C30; change to $1\mu F$, $35V$; Sanborn No. 8T-37; Vendor 150D155X9035B2 (SPR).
- CHANGE 13: Change Schematic and Parts List;
Q22; change 2N2552; Sanborn No. 16T-38; Vendor 2N2552 (TEX).
- CHANGE 14: Change Schematic and Parts List;
R89; change to 33Ω , $\pm 5\%$, $1W$; Sanborn No. 51D-330J; Vendor GB(AB).

HEWLETT-PACKARD/SANBORN DIVISION
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MAY 18, 1965

INSTRUCTION MANUAL
SANBORN RECORDERS
THERMAL (HEATED STYLUS)

IM-150-350-1

OPERATING NOTE:

Maximum stylus heat control settings should be used when recording frequencies in the middle to high frequency range of the recorder frequency response characteristics.

SECTION 1

DESCRIPTION

1. GENERAL DESCRIPTION

The Sanborn Dual Channel DC Amplifier Recorder Model 320 is a portable, two-channel recording system, designed for general purpose d-c recordings. Each channel is a stable, high-gain carrier amplifier which incorporates the dependability of transistor electronics with easily serviced printed-wiring plug-in boards. The input circuits are isolated from ground and include a guard shield, providing accurate recording in the presence of high common-mode voltages, with complete inter-channel isolation.

The system is contained in a heavy-duty carrying case with combination carrying handle and adjustable stand. This feature permits positioning the instrument for recording either vertically, horizontally, or at an angle of 20 degrees.

Inkless recordings are made by hot-wire writing arms on heat-sensitive Sanborn Permapaper chart, for fast accurate recording on true rectilinear coordinates. Approximately six inches of Permapaper chart is visible at all times for viewing the record as it is being made. Notes may be written directly on the Permapaper, using pencil, pen, or ballpoint pen. The four-speed chart drive is controlled by front panel push-buttons, and provides a wide range of recording speeds from 1 millimeter per second to 100 millimeters per second. A marker arm in the right margin of the chart, with an internal one-second timer, provides both coding and time indications for precise identification of recorded data. In addition to the output indicated by the recording galvanometers, an auxiliary front panel output jack is available for each channel and may be used to monitor the recording with an external indicating device such as an oscilloscope.

2. PERFORMANCE DATA

Channels:	Two-channel recording, each channel 5.0 centimeters wide.
Dimensions:	Approximately 13-3/4" long, 14" wide, and 9-3/4" deep.
Weight:	55 pounds.
Power Requirements:	103 to 127 volts, 60 cycles, single-phase, approximately 100 watts.
Recording Speeds:	1, 5, 20, and 100 millimeters/second.
Sensitivity:	0.5, 1, 2, 5, 10 and 20 millivolts/millimeter and volts/centimeter, corresponding to 25, 50, 100, 250, 500 millivolts, 1, 2.5, 5, 10, 25, 50 and 100 volts edge to edge of the 50 millimeter recording chart. A smooth gain control permits adjustment between 50% and 125% of calibration sensitivity.
Input Impedance:	0.5 megohm on millivolt ranges, 1.0 megohm on volt ranges, floating and guarded with inter-channel isolation. Source resistance should be below 10,000 ohms on millivolt ranges only.
Frequency Response:	DC to 125 cycles within 3 db at 10 millimeters peak-to-peak amplitude. DC to 50 cycles within 3 db at 50 millimeters peak-to-peak amplitude.
Response Time:	5 milliseconds maximum from 10% to 90% of final deflection; overshoot 4% or less.
Noise:	0.25 millimeter peak-to-peak maximum at calibrated gain.
Common Mode Voltage Tolerance:	±500 volts maximum.

2. PERFORMANCE DATA (Continued)

Common Mode Rejection:	140 db minimum at d-c; 120 db minimum at 60 cycles with no input unbalance; 100 db minimum at 60 cycles with 5000 ohms unbalance.
Drift:	0.25 millimeter maximum as a function of 10°C ambient temperature change in the range of 0°C to 40°C; 0.1 millimeter maximum as a function of line voltage variation from 103 to 127 volts.
Gain Stability:	Better than 1% with ambient temperatures from 0°C to 40°C; better than 1% with line voltage changes from 103 to 127 volts.
Limiting:	Electrical, approximately 115% of full scale.
Calibration:	10 millivolts $\pm 1\%$, internal. <i>2%</i>
Monitor Output:	Approximately 40 millivolts/millimeter deflection across at least 0.1 megohm load.
Linearity:	Maximum non-linearity 0.25 millimeter.*

*Sanborn Company measures and defines linearity as follows:

- Adjust zero-signal stylus position to mid-chart. Then apply DC signal for a 20-division up-scale stylus deflection. Measure amplitude of this DC signal carefully, in terms of input signal voltage.
- Now apply, in order, 0%, 25%, 50%, 75%, 100%, and 125% of the DC signal applied in step a.
- Now apply the same series of signals, with opposite polarity.
- Look for stylus deflections which almost exactly coincide with the heavy lines every five divisions on the chart. Deflections should coincide exactly at mid-scale and at +20 divisions. Linearity error is the distance on the chart by which each actual deflection misses its heavy line.

Note: to avoid hysteresis effects, perform test at a high paper drive speed.

3. FRONT PANEL DATA (EACH CHANNEL)

RANGE V/CM-MV/MM:	Multi-position rotary switch to attenuate the signal by fixed factors.
POSITION:	Control for adjusting the position of the writing arm on the recording chart.
CAL-ZERO-V/CM-MV/MM:	Four-position function switch which determines the operating mode of the amplifier.
GAIN:	Control for setting the gain of the amplifier so that the sensitivity values stated on the RANGE switch are accurate, and for providing intermediate sensitivities.
HEAT:	Control for adjusting the heat of the writing arm stylus for adequate trace density.
DAMPING:	Screwdriver-adjusted control for setting the damping of the galvanometer.
COMPENSATION:	Screwdriver-adjusted control for compensating for the loss in galvanometer response at high frequencies.
MONITOR OUTPUT:	Miniature jack to provide output signals for monitoring devices.
INPUT:	12-terminal connector to which the input signals are applied.
Controls common to both channels:	
POWER-TIMER-MARKER:	Series of five push-button switches at the left side of the panel for applying power, starting the one-second timing motor, or marking the recording.
PAPER SPEED:	Series of five push-button switches at the right side of the panel for selecting the recording speed.
INDICATOR:	Lights when power is applied.

OPERATING CONTROLS

RANGE
SET TO OBTAIN DESIRED WRITING ARM DEFLECTION EXPRESSED IN VOLTS PER CENTIMETER OR MILLIVOLTS PER MILLIMETER.

CAL-ZERO-V/CM-MV/MM
SET TO CAL TO INSERT CALIBRATION SIGNAL AND ADJUST SENSITIVITY WITH GAIN CONTROL; SET TO ZERO TO MAKE NO-SIGNAL POSITION ADJUSTMENT; SET TO V/CM OR MV/MM TO SELECT BASIC SENSITIVITY.

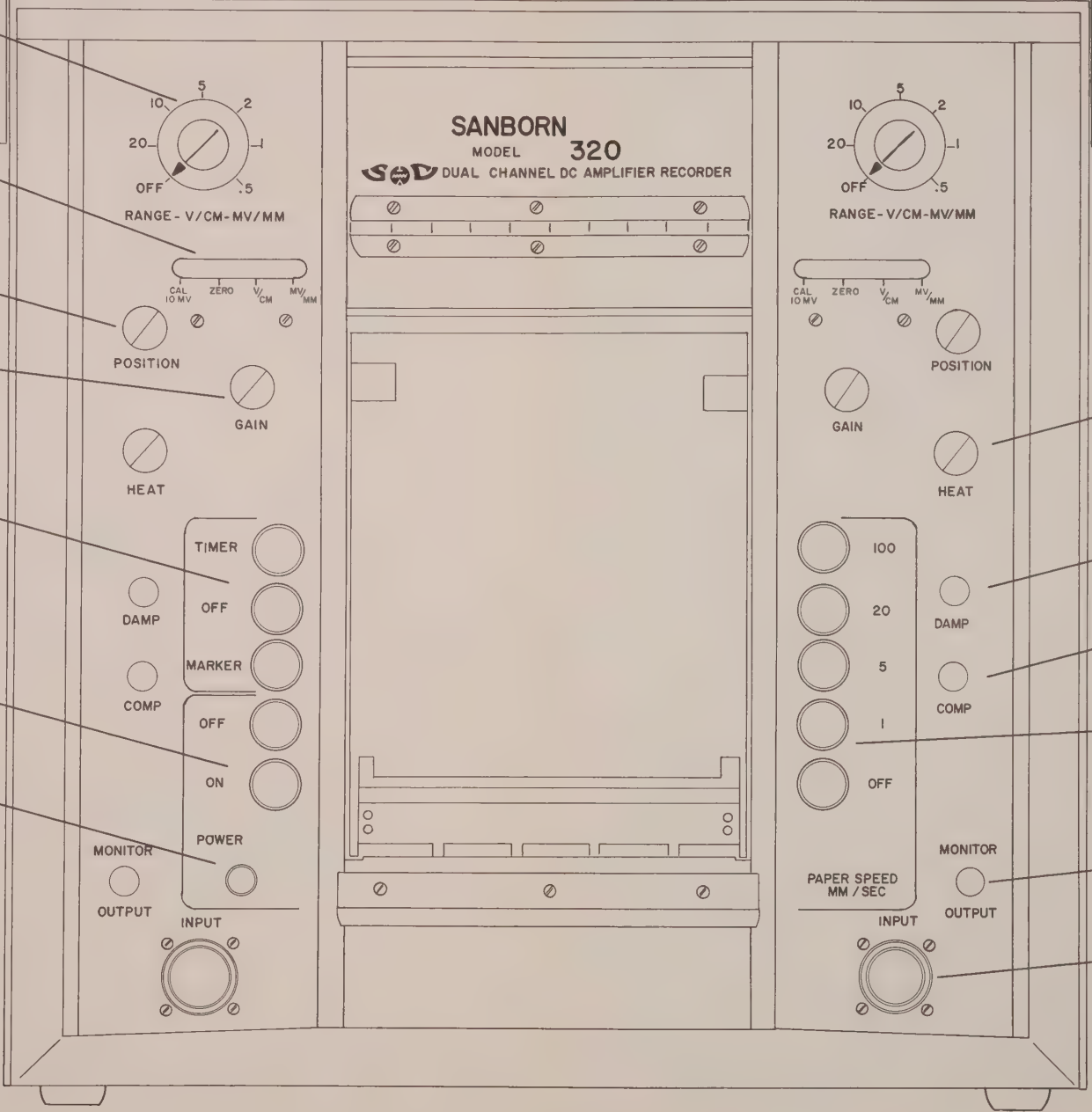
POSITION
SET THE ZERO INPUT SIGNAL POSITION OF WRITING ARM.

GAIN
ADJUST TO CALIBRATED OR INTERMEDIATE SENSITIVITY.

TIMER - MARKER
PRESS DOWN TIMER FOR ONE-SECOND TIMING MARKS. PRESS DOWN AND HOLD MARKER TO MARK RECORD FOR IDENTIFICATION. PRESS DOWN BOTH BUTTONS FOR SIMULTANEOUS TIMING AND MARKING.

POWER
PRESS DOWN ON TO TURN ON RECORDER.

INDICATOR
LIGHTS WHEN POWER IS APPLIED.



HEAT
ADJUST FOR GOOD TRACE DEFINITION.

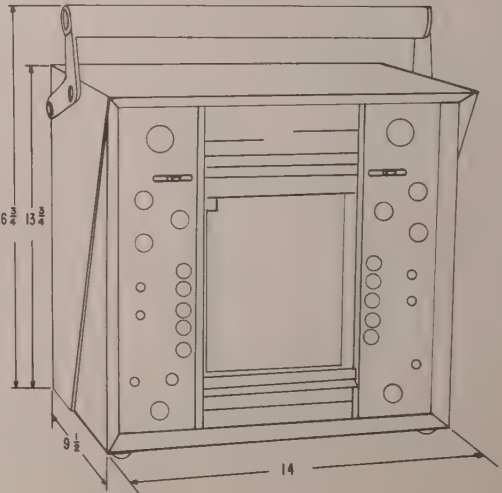
DAMPING
ADJUST FOR BEST GALVANOMETER DAMPING.

COMPENSATION
ADJUST FOR BEST GALVANOMETER RESPONSE.

PAPER SPEED
PRESS DOWN APPROPRIATE BUTTON TO SELECT RECORDING SPEED.

MONITOR OUTPUT
CONNECT EXTERNAL MONITORING DEVICE.

INPUT
CONNECT INPUT SIGNAL.



SANBORN DUAL CHANNEL DC AMPLIFIER-RECORDER MODEL 320

SECTION 2

INSTALLATION AND OPERATION

1. UNPACKING

Remove the recorder from its packing case and place on a table, bench top, or other firm, flat support. Open the accessory package and check the contents against those shown in the Replacement Parts List at the rear of this manual. Included in this package are spare writing arms, special tools, connectors, etc. These items will be used in the operation and maintenance of this instrument.

2. POWER CONNECTION

Most recorders of this model operate at 115 volts, 60 cycles, which is standard through most of the United States. Check the nameplate at the rear of the recorder before connecting to a power outlet; be sure that the line voltage and frequency are the same as that stamped on the nameplate. Contact the local power company if there is any doubt. (Special recorders are designed for 220/250 volts, 50 or 60 cycles; use these with the corresponding electric power. Do not use any recorder on d-c or 25 cycle a-c power lines.) Before connecting the recorder to the power line, press down on the push-button POWER OFF switch.

The power cord is stored in the carrying handle when not in use. Remove it and note the three-terminal plug at the end of the cord. This plug may be used directly on power outlets where a three-wire system is used. If the power system is of the two-wire type, use the three-wire adapter plug (accessory) between the power cord plug and the power outlet. Connect the short green lead of the adapter to a suitable ground.

3. OPERATING POSITION

The recorder may be used in a vertical or horizontal position, or at an angle of 20 degrees, with no effect on the operation of the instrument.

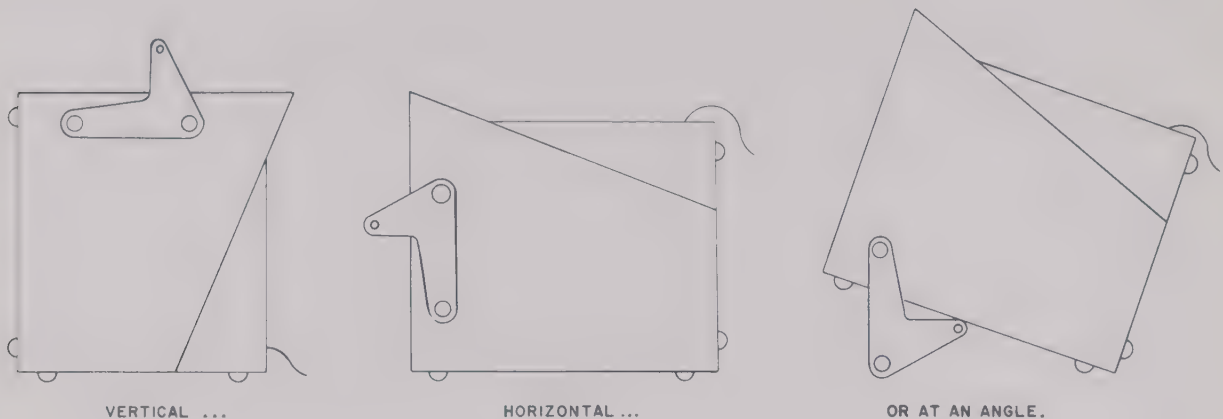


Figure 1

The latter position is ideally suited for bench or table top use, if the operator is seated. The recorder may be placed in this position by releasing the catch at each side of the carrying handle, then rotating the handle backwards, so that it supports the back of the case.

4. CHART LOADING

Sanborn Permapaper chart used in this recorder is supplied in 200 foot rolls. Charts printed with green coordinates are usually used in industrial applications (Sanborn part number 651-52); charts printed with black coordinates are usually used in medical applications (Sanborn part number 651-42). Special Translucent Permapaper is available and is suitable where Ozalid reproduction of the recording is desired (Sanborn part number 651-182). Each roll of Permapaper is marked with a star, 30 feet from the end of the roll, and serves as a warning to the operator that the paper supply is nearing exhaustion. Permapaper is installed in the recorder by following the illustrations in Figures 2 through 9 on the following pages.

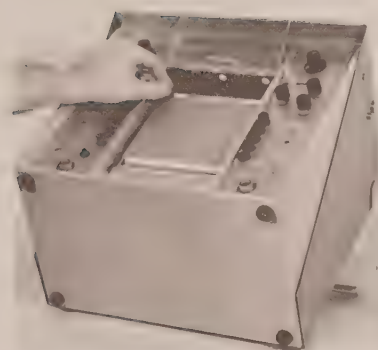


Figure 2. Turn the instrument off. Rotate the carrying handle beneath the case so that the recorder rests at a 20 degree angle. Lift the plastic viewing window up and push the writing table lock lever toward the galvanometers, releasing the table and lifting the writing arms from the writing edge.

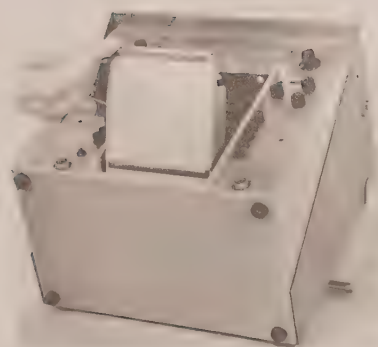


Figure 3. Lift the paper table up and toward the operator. If the paper supply is not completely exhausted, roll the remaining paper back on to the roll. Lift the paper roll out of its brackets and away from the paper drive compartment.

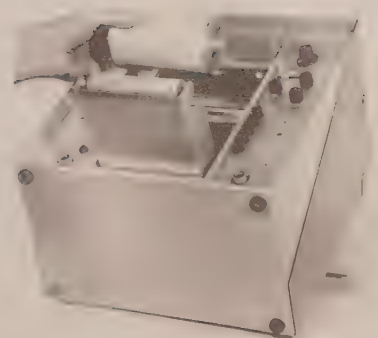


Figure 4. Remove the spool by pulling the left hand end disc out of the paper roll, then pull the paper roll core off the spindle. Place the new roll over the spindle. When installed, paper should leave the roll so that the grid lines of the chart are visible when pulled over the writing edge. Press the left end disc into the paper roll. Place the loaded spool in its mounting bracket, removable end disc to the left.

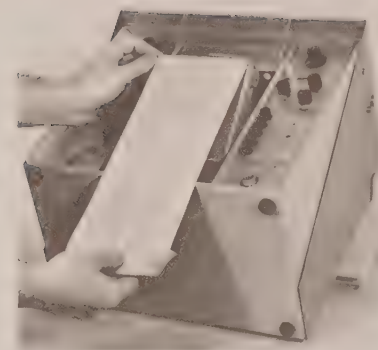


Figure 5. Pull the leading edge of the paper over the rubber brake roll and the writing edge. Now, lower the paper table into place, keeping the paper as taut as possible over the writing edge to keep from entangling the writing arms. Pull the lock lever back toward the operator.

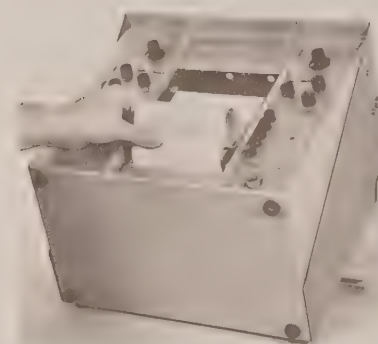


Figure 6. Fold the leading edge of the paper. Set the paper speed to 20 mm/second and start the motor. Feed the end of the paper down in between the drive roll guard plate and the end of the table. The drive roll will pick up the paper and carry it through, appearing at the other side of the guard plate and between the plate and the metal idler roller.

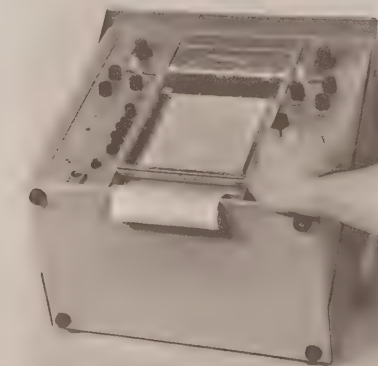
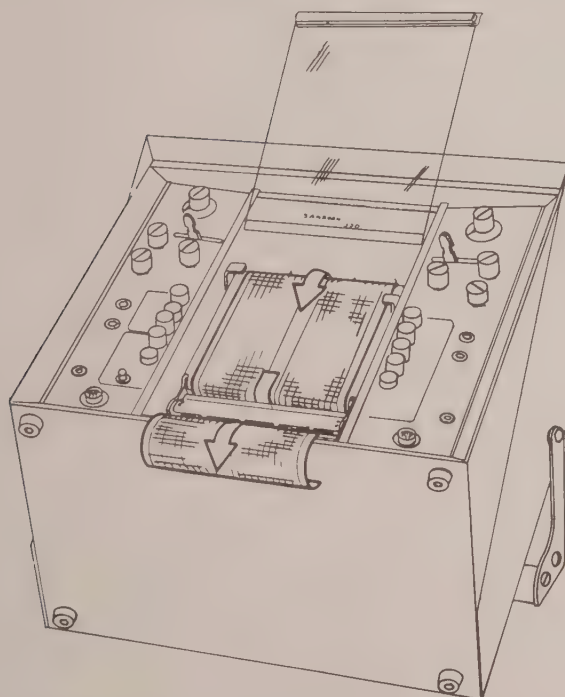
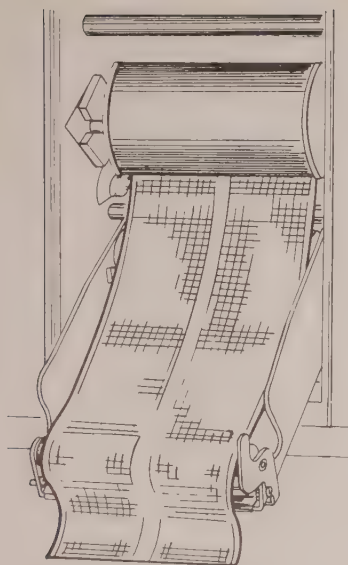


Figure 7. When the paper feeds satisfactorily, shut the drive motor off and lower the viewing window into place.



Paper Travel in Sanborn "320" Series of Recording Instruments.

4. CHART LOADING (Continued)

Figure 8

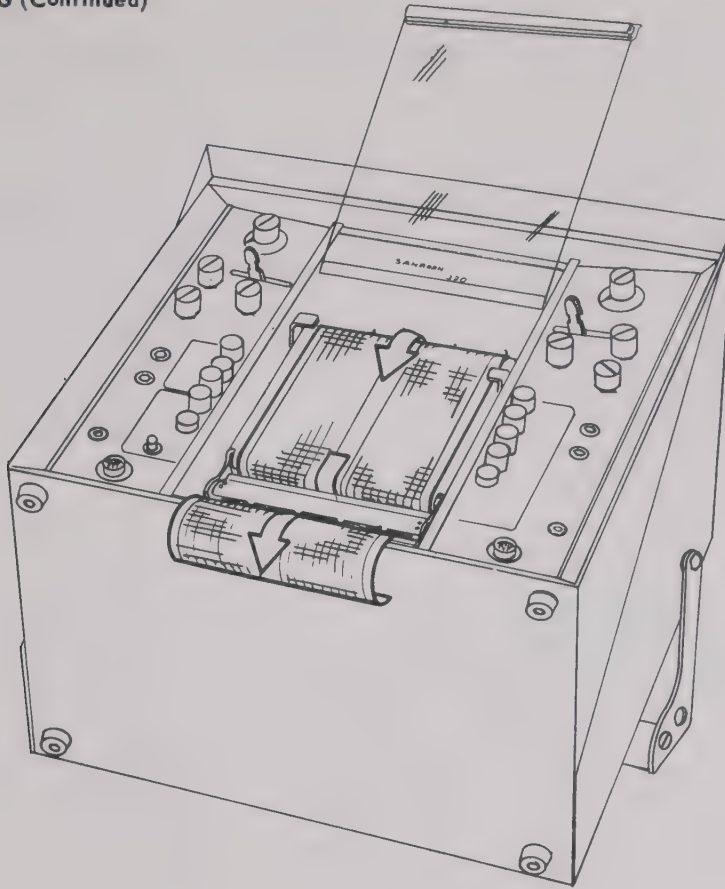
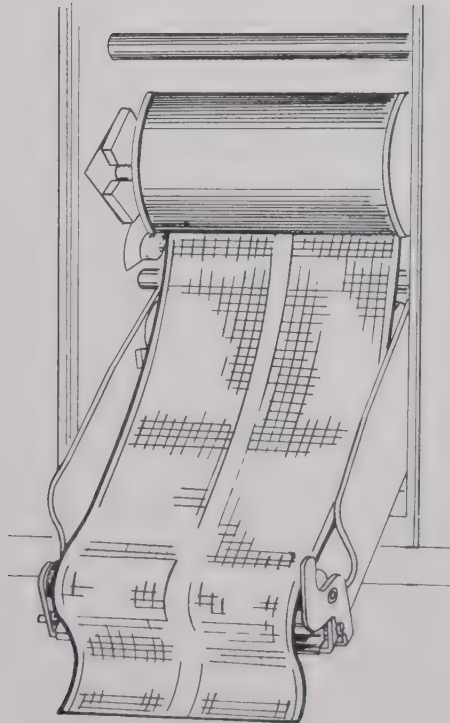
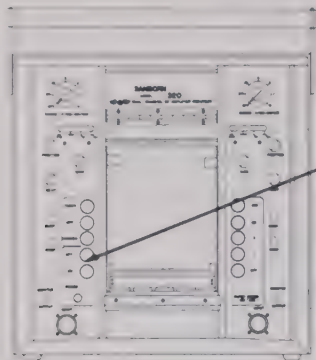


Figure 9



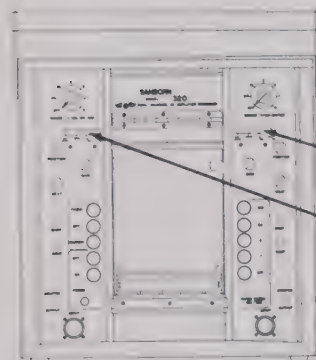
5. OPERATIONAL CHECK

The following tables present the most frequently used controls in the logical order of their use.



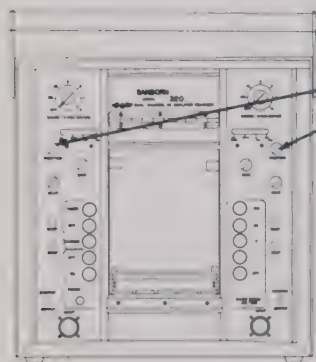
POWER ON-OFF:

Press the push-button POWER "ON" switch; the red indicator should light. Allow approximately five seconds for the amplifiers to stabilize before making other adjustments.



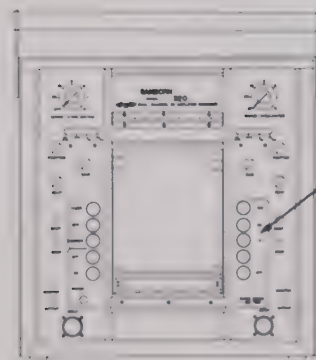
CAL-ZERO-V/CM-MV/MM:

Set the lever switches of both channels to ZERO. This permits setting the no-signal position of the writing arm.



POSITION:

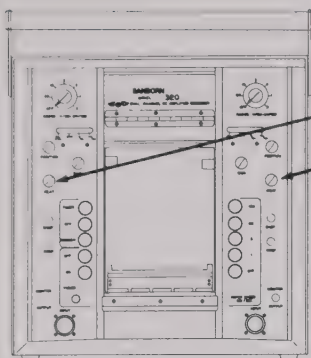
Turn the POSITION controls back and forth while watching the writing arms. It should be possible to move each arm over the entire width of its channel. Adjust the controls to place the arms in the center of each channel.



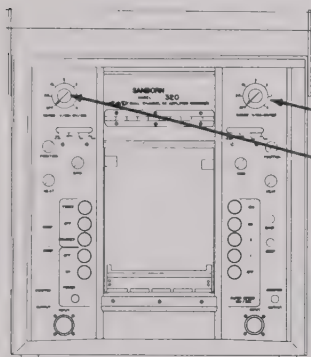
PAPER SPEED:

Press the 1 MM/SEC push-button switch; the paper should feed slowly out of the recorder. Next, press the 5, then the 20 and finally the 100 MM/SEC push-buttons; the paper speed should increase with each step. Return the paper speed to 5 MM/SEC.

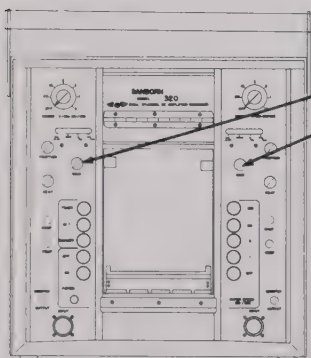
5. OPERATIONAL CHECK (Continued)

**HEAT:**

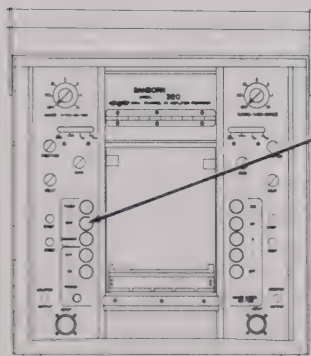
Turn the HEAT controls for both channels to each extreme while watching the baseline formed by the heated stylus. Adjust the controls for a firm, dense black baseline, with clear well-defined edges.

**RANGE V/CM-MV/MM:**

Rotate the RANGE switches fully clockwise to .5. This is the maximum sensitivity position of these controls.

**GAIN:**

Turn the GAIN controls of both channels fully counter-clockwise and set the CAL-ZERO-V/CM-MV/MM switches to CAL. Each writing arm will deflect approximately 10 mm. to the left. Slowly rotate the GAIN controls until the writing arms indicate exactly 20 mm. deflection. Record a series of square-waves by switching the CAL-ZERO-V/CM-MV/MM controls between CAL and ZERO.

**TIMER-MARKER:**

Press the MARKER button; a continuous power line frequency signal will be traced by the marker arm. Now, press the TIMER button; the marker arm will pulse at one-second intervals. Marking and timing may be done simultaneously by pressing both TIMER and MARKER buttons.

6. SIGNAL CONNECTION

This recorder includes a guard shield in the input circuit to obtain high common-mode rejection. Signals are connected to the front panel INPUT connector using the table below. After attaching signal leads, reassemble the mating connector for the INPUT socket by inserting the blue terminal assembly into the connector shell so that terminal M and N are next to the key plate, as shown in Figure 10. This allows the internal key to mate with the terminal assembly keyway.

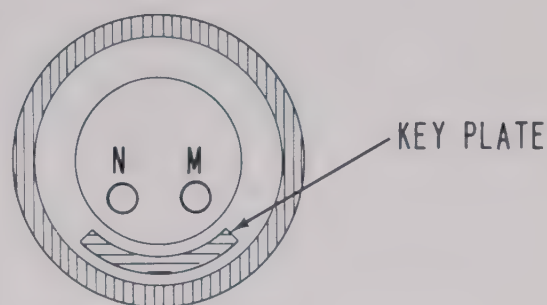
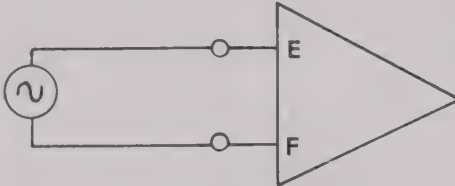
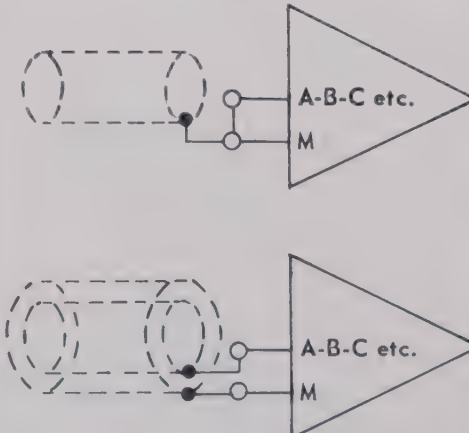
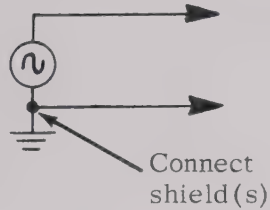


Figure 10

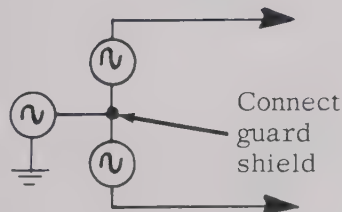
1. Connect the input signal . . .		<table border="1"> <thead> <tr> <th>When terminal "E" is:</th><th>and terminal "F" is:</th><th>then deflection is:</th></tr> </thead> <tbody> <tr> <td>+</td><td>—</td><td>up-scale</td></tr> <tr> <td>—</td><td>+</td><td>down-scale</td></tr> </tbody> </table>	When terminal "E" is:	and terminal "F" is:	then deflection is:	+	—	up-scale	—	+	down-scale
When terminal "E" is:	and terminal "F" is:	then deflection is:									
+	—	up-scale									
—	+	down-scale									
2. . . . then connect the shield(s)		Terminal M is the ground terminal; it always connects to the outer shield of the cable. The remaining terminals (A, B, C, D, H, J, K, L, N) are the guard shield terminals; one of these terminals always connects to the inner (guard) shield, or connects to terminal M if no guard shield is used.									

6. SIGNAL CONNECTION (Continued)

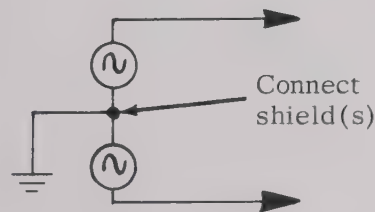
3. and finally, connect the shield(s) at the signal source.



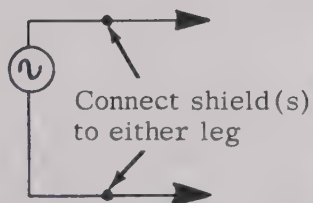
Single-ended input, one side grounded.



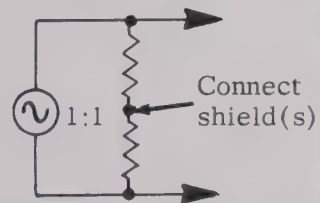
Balanced input in presence of common-mode component.



Balanced input with no common-mode component.



Floating input. Connect shield(s) to either signal leg or connect a 1:1 divider across the signal legs and connect shield(s) at mid-point. Resistors should be matched to within 1%.



7. RECORDING

After making the proper power and signal connections, turn the recorder on and adjust the POSITION controls to center the writing arms on the chart. Calibrate the recorder by setting the RANGE switches to .5 and the CAL-ZERO-V/CM-MV/MM switches to CAL, then adjust the gain controls for exactly 20 millimeters of writing arm deflection. Return the RANGE switch to OFF and set the CAL-ZERO-V/CM-MV/MM switches to V/CM.

Turn the recorder PAPER DRIVE on at the desired recording speed and slowly rotate the RANGE switches clockwise. If the writing arm deflections are too small for accurate interpretation at any setting of the RANGE switch, return this switch to OFF and set the CAL-ZERO-V/CM-MV/MM switches to MV/MM. Rotate the RANGE switches clockwise until the desired deflections are obtained. (Input voltage required for full scale deflection at any setting of the RANGE switch is given in the table below.) To mark or time the recording, press the appropriate push-button.

WARNING:

Do not apply over 50 volts (differential) to the input terminals on the MV/MM range or over 500 volts (differential) on the V/CM range. Common-mode voltage tolerance at all positions is ± 500 volts.

RANGE (V/CM)	VOLTS FOR FULL SCALE DEFLECTION AT CALIBRATED GAIN
.5	2.5 volts
1	5 volts
2	10 volts
5	25 volts
10	50 volts
20	100 volts
RANGE (MV/MM)	MILLIVOLTS FOR FULL SCALE DEFLECTION AT CALIBRATED GAIN
.5	25 millivolts
1	50 millivolts
2	100 millivolts
5	250 millivolts
10	500 millivolts
20	1000 millivolts

8. LOW LEVEL ELECTRICAL PHENOMENA

When measuring extremely low voltages, stray potentials in the external circuit may prevent full use of the amplifier's abilities. These potentials appear on the record or at the MONITOR OUTPUT as a signal which is difficult to distinguish from the value being measured, or as a signal which obscures the value being measured, or as a baseline shift when the RANGE switch is turned.

If the effects of stray potentials are too large to be ignored, one or more of the following procedures will usually reduce the disturbance to manageable proportions:

- a. Magnetic coupling can be reduced or eliminated by using an input cable whose conductors are twisted, by reducing the area of any conductor loops in the signal circuit, by isolating the input circuit from varying magnetic fields, or by magnetic shielding of the signal circuit.
- b. Capacitive coupling can be controlled by careful static shielding, that is, enclosure of leads in a metallic sleeve which is connected to guard or ground.
- c. Any impedance in the input circuit which is common to the input circuit and to some other circuit which carries a current (such as the earth, or a common ground bus, or a structural member used as ground) can introduce a stray signal into the input circuit. This can be reduced or eliminated by proper guarding and grounding.
- d. Thermo-electric effects are a common source of stray potentials which must be avoided when operating at high sensitivities. These may be reduced by avoiding contacts which are of dissimilar metals, and by keeping all contacts clean. The entire external circuit should be kept at a uniform temperature.

9. MONITORING

Recordings can be monitored with an oscilloscope or other high impedance indicating device by connecting to the front panel MONITOR OUTPUT jack, using the mating connector supplied as an accessory. The source resistance is 10,000 ohms. A load resistance of one megohm will change recorder calibration by 1%. Lower load resistances will require recalibration. Approximately 40 millivolts/millimeter of deflection is available.

SECTION 3

MAINTENANCE

1. INTRODUCTION

This section of the instruction manual provides the operator or repair technician with maintenance procedures for this instrument. All adjustments described in this section are factory set. Paragraphs 1 through 6 describe adjustments which may be made with the recorder in its case. Paragraphs 8 through 13 describe adjustments which must be made with the recorder removed from its case.

2. POWER FUSE REPLACEMENT

Primary power is supplied to the recorder through a single power fuse, located at the back of the case, near the power cord. (See Figure 11) To install a new fuse place the recorder in its vertical operating position and rotate the fuse cap one-half turn to the left, then lift out. Replace the open fuse with a 1.0 ampere slow-blow fuse (Bussman F02G1R00A). If the fuse continues to open after installing a replacement, inspect the recorder for wiring shorts, faulty components, etc. (See Paragraph 8).

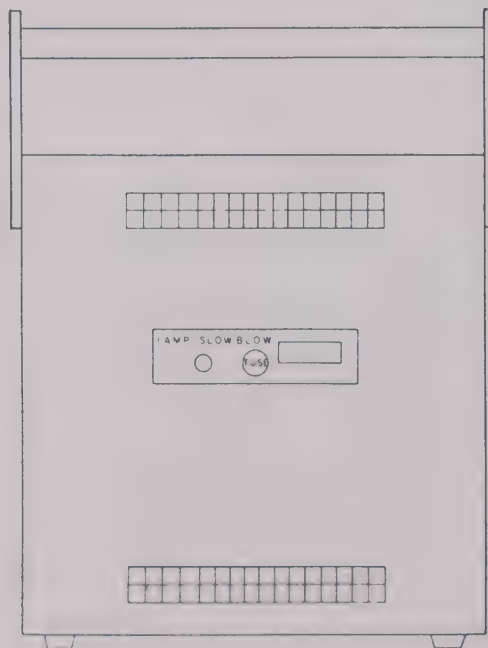


Figure 11

3. WRITING ARM MAINTENANCE

This recorder uses three writing arms: the two galvanometer writing arms (Model 398), and the marker arm (Model 401). The galvanometer writing arms are identified by the A-shaped frame attached to the top of the galvanometer. The small nichrome ribbon at the end of the frame, resting on the edge of the paper table, is the writing stylus. There are four adjustments associated with the galvanometer writing arms:

- The clamping screw which sets the level of the arm and secures it to the galvanometer.
- The pressure adjustment screw which sets the force of the stylus on the writing edge.
- The stylus centering adjustment which sets the arm to mechanical center.
- The writing arm limiters which restrict the travel of the arm to the recording chart.

These adjustments can be identified in Figure 12.

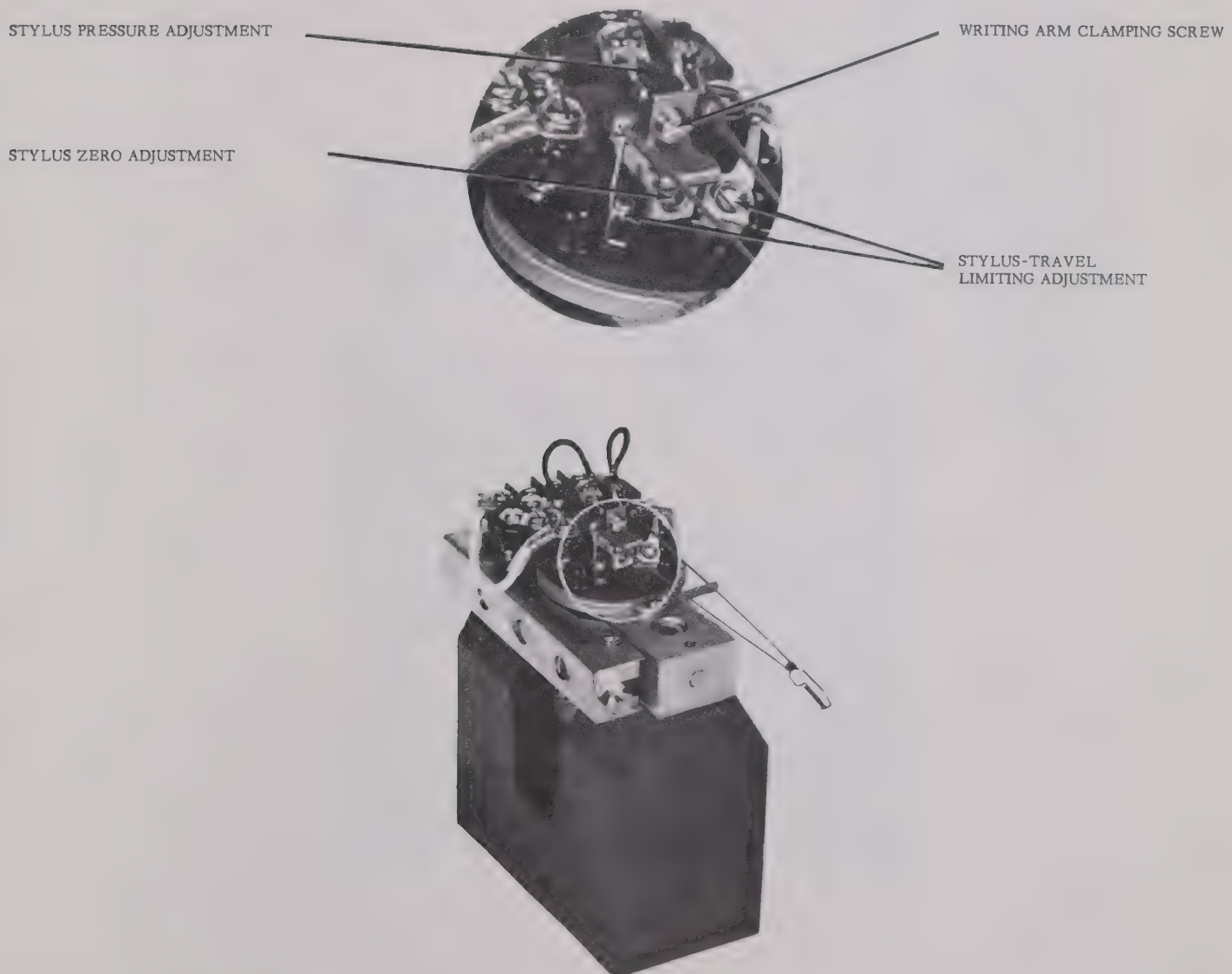


Figure 12

3. WRITING ARM MAINTENANCE (Continued)

The need for writing arm maintenance may be indicated by a blurred or indistinct baseline. This will require one or more of the following adjustments.

a. STYLUS PRESSURE

Check the pressure of the stylus on the writing edge with the Stylus Pressure Tester Model 442, as shown in Figure 13. This scale is included as an accessory.

To calibrate the scale:

- (1) Remove the 2 gram standard from the bottom of the scale and hang it on the scale hook; there is a hole in the standard for this purpose.
- (2) Hold the Tester vertical so that the scale hangs free. Slide the index ring to position its top edge opposite the 2 gram mark of the scale.
- (3) Remove the standard weight.

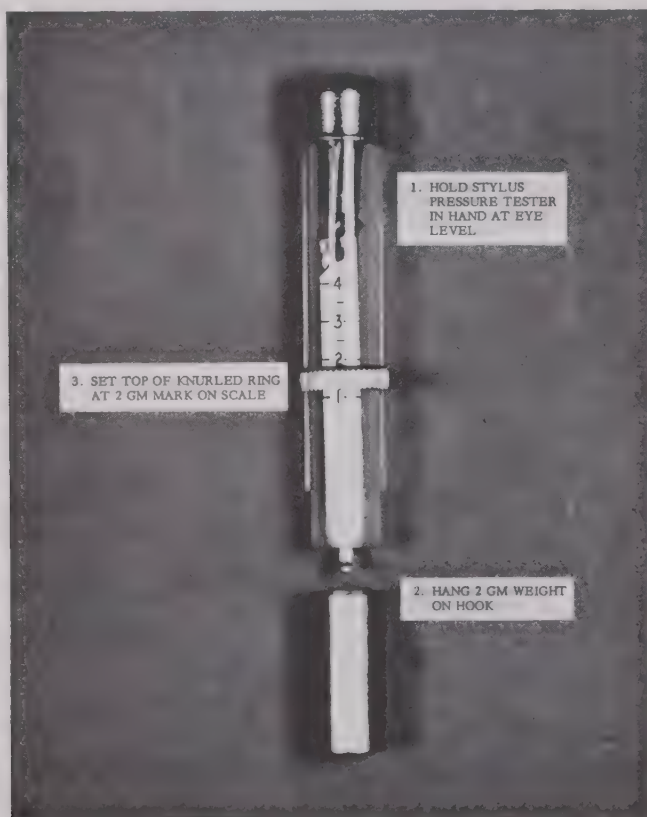


Figure 13

3. WRITING ARM MAINTENANCE (Continued)

To adjust the pressure:

Turn off the recorder and lift open the transparent viewing window.

Place the scale hook under the section of the stiff-wire arm nearest the point where the stylus ribbon contacts the Permapaper.

Lift the Tester perpendicular to the writing arm so that the scale does not rub against the inner wall of the tube; be sure the stylus is not stuck to the plastic coating of the paper. Read the stylus pressure indicated just as the stylus leaves the paper; it should measure 1.5 to 2 grams.

(See Figure 14).

Two holes are provided at the top of the case behind the galvanometers (one for each channel) to allow making adjustments on the stylus pressure adjustment screw. With a long, thin screwdriver inserted through the adjustment hole stylus pressure can be increased by loosening the adjusting screw or decreased by tightening the screw. After making an adjustment, recheck the pressure with the Pressure Tester.

b. STYLUS CLEANING

Accumulations of Permapaper coating on the stylus ribbon may prevent clear, well defined recordings. If the ribbon is only lightly coated, it can be burned away by increasing the stylus temperature.

- (1) Push the writing table lock lever (at the top left edge of the paper table) toward the galvanometers, releasing the table and lifting the writing arms from the paper.
- (2) Turn the paper drive on at its highest speed.

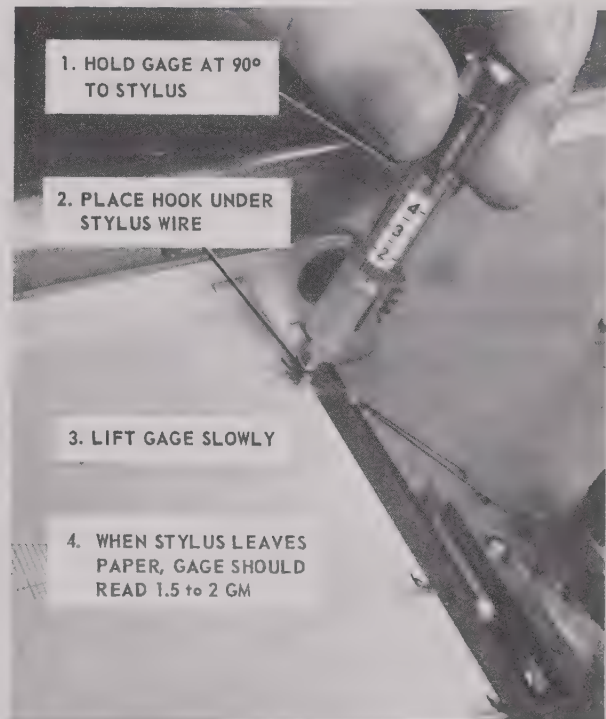


Figure 14

3. WRITING ARM MAINTENANCE (Continued)

- (3) Rotate the stylus HEAT control to its maximum clockwise setting and allow the recorder to run for a few moments. The increased temperature may be sufficient to burn off the coating. If the preceding steps do not provide a better trace remove the writing arm.
- (4) Loosen, but do not remove, the writing arm clamping screw. (See Figure 12). Lift the arm free, taking care that the magnetic pull does not cause the screwdriver to damage the galvanometer.
- (5) Examine the surface of the hot-wire stylus. If the stylus is dirty, clean it by scraping gently with a sharp blade or rub it carefully with fine sandpaper. Do not use steel wool or abrasives containing metal particles. If the ribbon is bent, straighten it with tweezers. Replace the writing arm, tighten the screw, and check the trace. Check the stylus force with the Stylus Pressure Tester.
- (6) If the above adjustments do not provide a more clearly defined trace, remove and replace the writing arm with a new one.
- (7) If the traces of both channels are blurred, check the Permapaper as it passes over the top of the writing edge. There should be no sign of looseness; the paper should be taut as it passes over the edge so that the stylus has as sharp and small a surface as possible on which to write. If necessary, adjust the paper brake for optimum paper tension. (See Paragraph 6).

c. MECHANICAL CENTERING

When the instrument is turned off, the stylus at the end of each writing arm should be centered in the middle of its ruled chart area, within ± 1 millimeter. If adjustment is required, loosen the stylus zero adjustment screw (See Figure 12) using the spline wrench included as an accessory. Move the writing arm to the correct position and tighten the screw.

d. MECHANICAL LIMITING

Each galvanometer is provided with two mechanical stops to prevent peak deflections from causing entanglement of the writing arms, or hooking of the arms on the ends of the writing table. To adjust the stops:

- (1) Using a non-magnetic screwdriver, loosen the clamping screw of the galvanometer stop nearest the marker arm. Adjust this stop (slotted holes are provided) to limit writing arm excursion to between one and two millimeters beyond the ruled area for the chart.

3. WRITING ARM MAINTENANCE (Continued)

- (2) Adjust the remaining stop of this galvanometer and the stops of the other galvanometer to limit writing arm excursions to two millimeters beyond the ruled area of the chart.
- (3) Turn on the recorder and rotate each POSITION control from one extreme to the other checking that writing arm travel is within these limits. If not, turn off the recorder and readjust the limiters.

e. MARKER ARM

The construction of the marker arm in the right margin of the chart is similar to the galvanometer writing arm. It is attached to a spring arm by a clamp and screw assembly on which is mounted a small coil. A low a-c voltage from the power supply excites the coil to produce line frequency vibrations of the arm.

Procedures described in step b can be used in cleaning this arm. To remove the arm for replacement, remove the two screws which clamp the heater leads to the terminal block and loosen the small clamping screw on the spring arm. After installing a new arm, be sure these screws are tight.

4. FREQUENCY COMPENSATION AND DAMPING ADJUSTMENTS

Each channel of the recorder is adjusted for optimum response at high frequencies with its COMPENSATION control (R61) and DAMPING control (R64). These are front panel screw-driver adjustments.

- a. Connect a variable frequency audio oscillator to the recorder INPUT connector for the channel under adjustment. Set the frequency of the oscillator to 10 cycles and turn the recorder on.
- b. Set the paper speed to 5 mm/second and adjust the stylus HEAT control for maximum heat.
- c. Set the DAMPING and the COMPENSATION controls to the approximate centers of their ranges.
- d. Adjust the level of the signal or the sensitivity of the channel for a 10 mm. peak-to-peak deflection, centered about the chart center line.
- e. Raise the oscillator frequency to 125 cycles while keeping its amplitude constant. Now, adjust the COMPENSATION control to give a 7 mm. peak-to-peak deflection.

4. FREQUENCY COMPENSATION AND DAMPING ADJUSTMENTS (Continued)

- f. Reduce the oscillator frequency to 45 cycles and adjust the DAMPING control for a peak-to-peak deflection of approximately 9-1/2 mm.
- g. Reduce the oscillator frequency to 10 cycles and adjust the signal level to obtain a 10 mm. deflection again.

These adjustments should provide the specified sine wave and transient response. To check the latter:

- h. Rotate the RANGE switch to .5, position the writing arm to 10 mm. to the right of center with the POSITION control, and calibrate for 20 mm. across the center of the chart.
- i. With paper speed at 20 mm./second and stylus heat adjusted for good definition, throw the lever from ZERO to CAL and back. The trace should rise smoothly to its final amplitude and should not overshoot more than 4% (0.8 mm) if at all. (See Figure 15).
- j. If the overshoot is excessive, adjust the DAMPING control to reduce it.

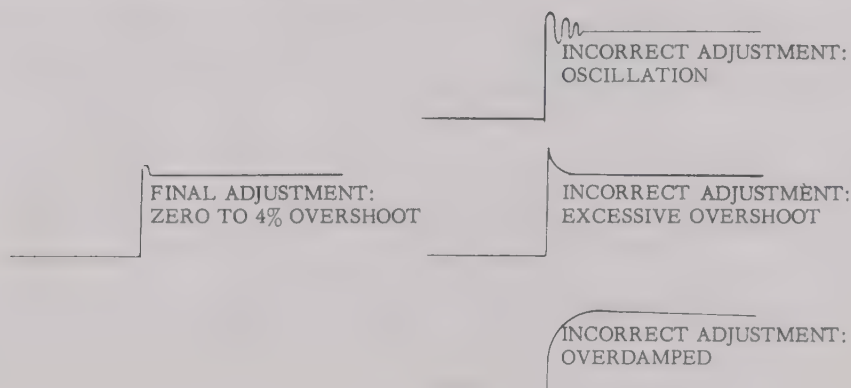


Figure 15

5. PARALLAX CORRECTION

Parallax is present when the timing lines of the Permapaper are not parallel to the writing edge. It is important that the entire length of each timing line should cross the edge at the same instant.

To check for parallax:

- a. Run off two or three feet of paper at the highest speed. Now, turn the chart drive off so that the paper remains taut over the writing edge.

5. PARALLAX CORRECTION (Continued)

- b. Mark the extreme left and right edge of the paper at the point where it crosses over the edge. Marking may be done by rubbing the surface of the Permapaper where it crosses the edge with a smooth straight object. Be careful that the mark is made with the marking tool crossing the edge at a constant angle; if the marking tool crosses at a variable angle, a false indication of parallax will result.
- c. Run the paper a few millimeters to bring the marks into view. They should be on or equidistant within 0.25 millimeter from the same grid timing line at both extremes of the paper; if they are, the timing lines are parallel to the edge and no corrections are necessary.
- d. If parallax does exist, it is caused by the writing edge and a paper supply roll which are not parallel. The first step to take to correct this condition is to try another roll of Permapaper, eliminating the possibility of incorrectly rolled paper.
- e. If the preceding step does not correct the error, open the paper table and note the two eccentric stops above the paper spool. The paper table rests on these when closed. Close the paper table and examine it to be sure it is properly seated. Tap the paper table with a metal object evenly along a line parallel to, and one inch in front of, the writing edge. If the sound of the tapping changes from one side to the other, adjust the eccentric stop under the paper table where the tapping sound becomes louder or hollower.

Lift the paper table and adjust the appropriate eccentric with a large screwdriver until a setting is found at which tapping sound indicates the paper table seats correctly; tighten the hexagonal nut holding the eccentric stop to secure the stop adjustment.
- f. Examine the writing edge which clips over the edge of the writing table. If it is not flush with the edge of the table, press in at both ends.

6. PAPER TENSION AND TRACKING ADJUSTMENT

The paper drive is designed to track the Permapaper accurately within limits of ± 0.25 millimeter. If the chart drifts to one side in its travel over the writing edge make the following checks.

- a. When mistracking occurs immediately after inserting the Permapaper, the paper has probably been inserted into the drive at an angle, or has not been centered. This type of mistracking will correct itself in the first few feet of paper run through the drive. If mistracking is present to an excessive degree, roll the paper back and insert it into the drive again with more attention to the loading technique.

6. PAPER TENSION AND TRACKING ADJUSTMENT (Continued)

- b. Check to see that the paper is riding over the rear brake roller, under the front pressure roller, and is leaving the recorder freely from the front. If the paper is caught under or around either roller, an extra load is placed on the drive mechanism which accentuates any other problems of paper feed or tracking.
- c. If the mistracking persists, remove the roll of Permapaper from the spindle and check the end faces of the roll with a straight edge to see if it is perfectly flat. Flatten it if necessary by tamping the convex end face.
- d. If mistracking still occurs, or there is a tendency for the paper to tear as a result of too much tension, or the paper passes over the writing edge too loosely to obtain a distinct trace, the braking mechanism located inside the rubber brake roll must be adjusted. Adjustment is made by lifting the paper table and turning a screw at the right hand end of the brake roll. When the screw is brought out toward the end of the roll, the brake tension is decreased. When the screw is turned toward the center of the roll, the tension is increased. Ideal braking is obtained when the paper is tight as it passes over the writing edge.

The brake tension is set at time of manufacture and normally does not require further adjustment. However, when using translucent Permapaper, more tension is required. Readjust the brake when returning to regular paper.

7. CASE REMOVAL

To perform the adjustments described in the following paragraphs, it will be necessary to remove the recorder from its two-piece carrying case

- a. Place the recorder in its vertical operating position.
- b. Remove the four screws from the back of the case and the single screw on each side of the case.
- c. Now, carefully lift the outer part of the case away from the inner part. The recorder is not secured to the inner half of the case; for removal, simply lift the recorder out and place on a work bench.

8. INSPECTION

- a. Blow out both the chassis and the case with an air hose.
- b. Clean the panel and the case with a cloth moistened lightly with alcohol or other mild cleaning solution. Wipe dry with a soft, clean cloth. Be careful not to scratch the panel finish.
- c. Inspect the recorder for loose components, particularly plug-in components such as transistors, mounting boards, etc.
- d. Check that all panel mounted components are securely in place. Check that all controls turn firmly and smoothly.
- e. Inspect for damage, visually and by smell. Look for burned or worn insulation, leakage, damaged resistors, capacitors, etc. Inspect for rust, corrosion, etc.
- f. Check the paper drive system. First remove the writing arms and the Permapaper. Clean the writing edge and viewing window with a cloth moistened with alcohol or other mild cleaning solution; do not use an abrasive. Inspect the writing arms; if the styli are dirty or misshapen, refer to Paragraph 3 for cleaning and adjustment.

9. LUBRICATION

Lubricate the paper drive motor at least every three months with electric motor oil or with SAE-10 motor oil. Do not use rust preventive or cleaning oils. Oil cups are located at both ends of the motor, above the bearings. For continuous duty, more frequent checks are recommended.

Lubricate the gear chain drive and the gear train at least once a year with Anderol L-732. Use a sash brush to apply the lubricant.

Do not over-lubricate; wipe up overflows or spills.

10. CALIBRATION CELL REPLACEMENT

Calibration voltage is supplied by a 1.34 volt mercury cell for each channel. The life expectancy of these cells is approximately two years. If it should become impossible to obtain at least 20 millimeters of writing arm deflection when calibrating, remove and replace the cell of the affected channel.

- a. Remove the amplifier plug-in board of the channel affected.
- b. Remove the guard shield can from the CAL-ZERO-V/CM-MV/MM switch (S2).
- c. Identify the cell which is soldered to terminal lugs which are fastened to the printed wiring board. Unsolder and install a fresh cell (Sanborn part number 2A-15A), then reassemble the recorder.

11. SUPPLY VOLTAGE ADJUSTMENT

The regulated supply voltages, + and -12 volts d-c, are set with potentiometer R68. This control is located on the power supply plug-in board. Early Model 320 Recorders use plug-in board assembly Model 320-100-C12; later Model 320 Recorders use plug-in board assembly Model 320-100-C24.

- a. To adjust regulated supply voltages using Model 320-100-C12 boards:
 - (1) Identify screwdriver adjusted potentiometer R68.
 - (2) Connect a d-c voltmeter of at least 10,000 ohms-per-volt resistance between chassis ground and the jumper wire adjacent to the board connector.
 - (3) Adjust R68 for exactly -12 volts ± 0.2 volt.
- b. To adjust regulated supply voltages using Model 320-100-C24 boards:
 - (1) Identify screwdriver adjusted potentiometer R68.
 - (2) Connect the test meter between the test point at the end of resistor R69 (labeled $\leftarrow 12V$) and chassis ground.
 - (3) Adjust R68 for exactly +12 volts ± 0.2 volt.

12. TRANSISTOR REPLACEMENT

Transistors used in this instrument are reliable under normal operating conditions. Excessive heat is the most common cause of failure, and in the case of power transistors, is sometimes caused by loose mounting screws. Transistor replacement requires a few precautions. For socket mounted types, be careful that the replacement transistor has its pins properly aligned with its socket holes. Do not force it into the socket; it should go in easily. Also, when replacing two or more transistors simultaneously, be sure to install the transistors in the proper sockets. Replacement of larger transistors, requiring unsoldering of leads, is more critical. Do not allow the soldering iron to overheat the transistor; use a pair of long-nose pliers to grasp the leads and to act as a heat sink. Be sure to mount the replacement transistor securely to the heat sink. Transistor Q13 (2N158) is supplied with color coded leads as shown in Figure 16a. Emitter, base, and collector terminals of output transistors Q18 and Q19 (H5G1) are identified by the letters e, b, and c. Reassemble this transistor as shown in Figure 16b.

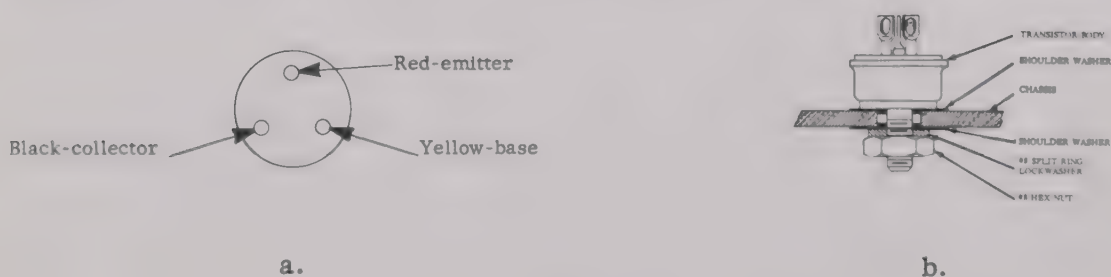


Figure 16

13. PRINTED WIRING BOARD TECHNIQUES

The printed wiring boards used in the Model 320 are the result of many experiments at Sanborn Company to find the best designs consistent with ease in manufacture and servicing. The following procedures will help in making fast, trouble-free removal or replacement of components.

- a. Remove the screws which hold each printed wire board to the recorder chassis, then pull the board from its connector, taking care not to damage the components.
- b. For amplifier boards, remove the screws holding the shields to the boards.
- c. Use as little heat in soldering as possible. A 25 watt soldering iron with a small pointed tip is recommended. Touch the tip of the iron to the lead of the part to be removed, not to the printed board itself. Apply heat to the soldered side of the board - not to the component side.
- d. When removing a component, or when tinning a lead, hold the lead itself, next to the body of the resistor, condenser, etc., with pliers, as a heat sink to prevent overheating of the component.
- e. Carefully clean and tin the leads of the replacement part. Hold the lead with pliers as described in step d.
- f. Now insert the new part in place through the holes in the printed wire board, with the replacement component held against the board. Carefully solder in place with a minimum of heat, using a pair of long nose pliers as a heat sink adjacent to the replacement part.
- g. Replace the shields on the amplifier boards. Carefully insert the printed wire board into its connector; do not bend or use force. Replace the mounting screws removed in step a.

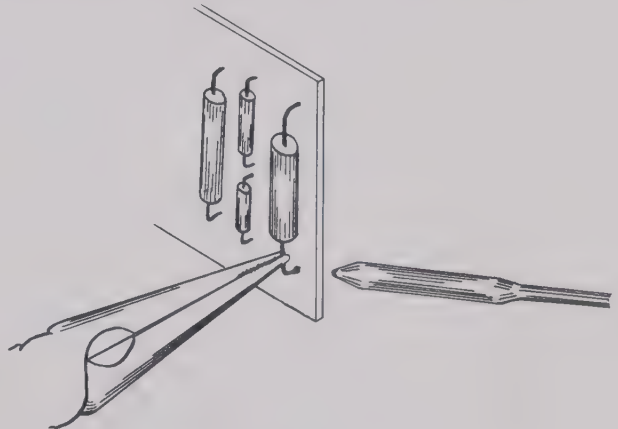


Figure 17

SECTION 4

CIRCUIT THEORY

1. INTRODUCTION

Each channel of this instrument contains a sensitive and stable recording carrier amplifier. A 1200 cycle transistor modulator in the input circuit reverses the polarity of the input signal 2400 times per second. The resulting output signal is a 1200 cycle amplitude-modulated square-wave. The height of this square-wave is proportional to the amplitude of the input signal; the phase of the square-wave (0° or 180°), with respect to the excitation signal of the modulator, represents the polarity of the input signal. Conversion of the input signal (which may be d-c or low frequency a-c) to a 1200 cycle square-wave allows the signal to be amplified by an a-c amplifier, avoiding the baseline drift which might otherwise occur in a d-c amplifier of the same sensitivity.

2. GENERAL

This section of the instruction manual is used in conjunction with the schematic and block diagrams found at the rear of the manual. Note that the schematic diagram divides naturally into sections, determined for the most part by printed wiring boards. Only one channel of the instrument is represented on this diagram.

- . . . In the lower left-hand corner of the diagram you will find the circuit details of the input and modulator section on assembly 320-100-C30.
- . . . To the right of the input circuit may be found the RANGE (attenuator) switch circuit details on assembly 320-100-C3.
- . . . At the far right of the diagram is the power supply, oscillator and voltage regulator circuits. This printed wiring plug-in board is common to both channels and is identified as assembly 320-100-C24.

2. GENERAL (Continued)

- . . . At the top of the diagram, running from left to right, is the heart of the recorder, containing the a-c amplifier, demodulator, and driver amplifier sections. This is a plug-in printed wiring board and is identified as assembly 950-3400.
- . . . In the right center of the diagram you will find the circuits for the stylus heat, push-button control, amplifier power output stage, galvanometer and marker, paper drive and timing motor, and power supply circuits.

3. COMMON-MODE (IN-PHASE) SIGNALS

Before discussing circuit theory of the amplifier, it is important to describe the signals which may be applied, and show what happens to them.

Assume an amplifier which has two input terminals. Call one terminal "A" and the other terminal "B". The amplifier ideally responds to the voltage between "A" and "B". This voltage between "A" and "B" is the "differential voltage".

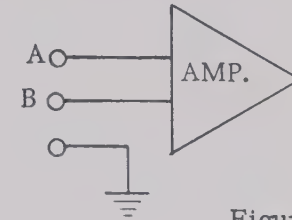


Figure 18

Mathematically, the differential voltage can be expressed as $B - A$ or as $A - B$. So if terminal "A" is at +1.3 volts, and terminal "B" is at -1.3 volts, this amplifier will respond to the 2.6 volts differential voltage. But now assume that terminal "A" is at +3 volts, and terminal "B" is also at +3 volts. Obviously, the differential voltage is zero. The question is: will the +3 volts at both "A" and "B" interfere with the proper operation of the amplifier? This +3 volts is a "common-mode" or "in-phase" component, because it appears at both input terminals with the same voltage and the same polarity at the same time. Mathematically, the common-mode (or in-phase) component =

$$\frac{(\text{volts at "A"}) + (\text{volts at "B"})}{2}$$

Since the amplifier is intended for differential measurements only, it should ignore this common-mode voltage completely. But no electronic amplifier is perfect, and the common-mode voltage may have some slight effect. The characteristic known as "common-mode rejection" is the figure which shows how perfectly the common-mode component is kept from affecting the amplifier.

3. COMMON-MODE (INPHASE) SIGNALS (Continued)

Practical examples of common-mode voltages are: capacitive pickup on input signal cables; a signal circuit which is elevated above or below ground potential because of ground loops; a signal source which inherently includes a common-mode component because of its circuit design, etc.

This amplifier achieves a high common-mode rejection ratio because of its input circuit design. In this amplifier, the input signal is applied to a transformer through a modulator which expresses the input signal as a 1200-cycle square-wave. Any common-mode component is (ideally) applied equally to both terminals of the transformer; as a result, no common-mode component is applied across the primary so as to induce a common-mode component at the secondary. In addition, a dual shield between the primary and secondary of the transformer prevents capacitive coupling of common-mode signal components, between the primary and secondary of the transformer.

These circuit procedures for rejecting common-mode signal components are effective only as long as a portion of the common-mode does not become transformed in some way into a differential signal; if this happens, then the amplifier is unable to discriminate against this differential component, but will amplify it along with any of the other differential signals which the amplifier is designed to accept.

The cause and cure for this problem is discussed in the following paragraph.

4. GUARD SHIELD THEORY

The preceding paragraph showed that the amplifier will reject common-mode signals except for any part of the common-mode signal which may become transformed into a differential signal before it reaches the amplifier input terminals. This paragraph shows how a part of the common-mode signal can be changed into a differential signal, and what to do to prevent it.

Assume a signal source connected to the amplifier as in Figure 19:

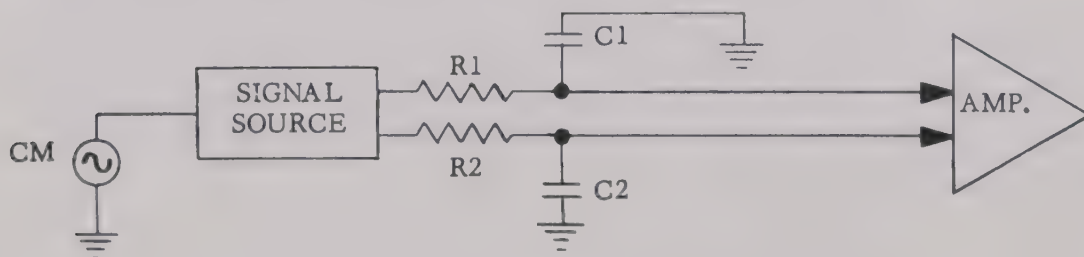


Figure 19

4. GUARD SHIELD THEORY (Continued)

With this circuit, CM is the common-mode signal, R_1 and R_2 are the series resistances of the two sides of the signal source and the cabling (the general case would use Z_1 and Z_2 as the two source impedances), and C_1 and C_2 are the cable and stray capacitances of the two sides of the signal source and cabling.

In the upper lead, R_1 and C_2 form a low pass filter, so that (when CM is an a-c signal) only a portion of CM appears at the upper terminal of the amplifier. Similarly, R_2 and C_2 form another low pass filter, so that only a portion of CM appears at the lower terminal of the amplifier. These portions may be large or small.

Now, if the two sides of the circuit are perfectly balanced ($R_1 = R_2$, $C_1 = C_2$) then the portion of CM which appears at the upper terminal is exactly the same as the portion of CM which appears at the lower terminal: the common-mode signal remains a pure common-mode signal, which the amplifier is designed to reject.

However, if the two sides of the circuit are not perfectly balanced, then the portion of CM which appears at the upper terminal is no longer exactly the same as the portion of CM which appears at the lower terminal; we have transformed a part of the common-mode signal into a differential signal, which the amplifier will not reject, but will treat as any other differential signal. This spoils the apparent common-mode rejection ratio. The same effect occurs with d-c signals, where the unbalance lies in R_1 and any leakage resistance in parallel with C_1 , compared with R_1 and the leakage resistance across C_2 .

What is needed here is a method of keeping an unbalanced signal source from transforming a portion of the common-mode voltage into a differential voltage. This is done with a guard shield.

The guard shield circuit uses two shields: an inner shield, connected to the common-mode voltage, and an outer shield, connected to the amplifier ground, as shown in Figure 20.

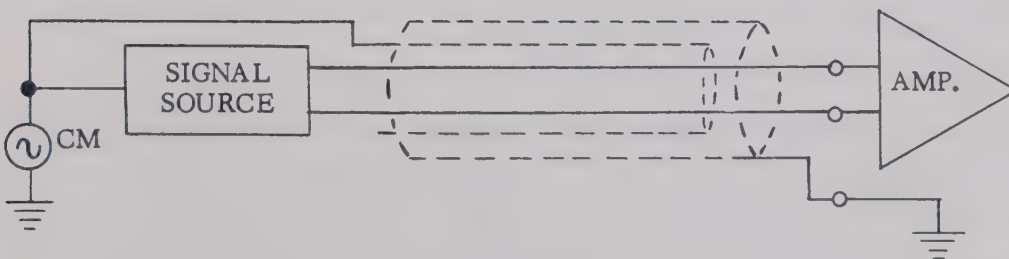


Figure 20

4. GUARD SHIELD THEORY (Continued)

With this inner shield connected, no current will flow through the stray capacitances and cable capacitances because both sides of the capacitances are at the same common-mode potential.

The equivalent circuits showing the resistances and the capacitances are shown in Figure 21.

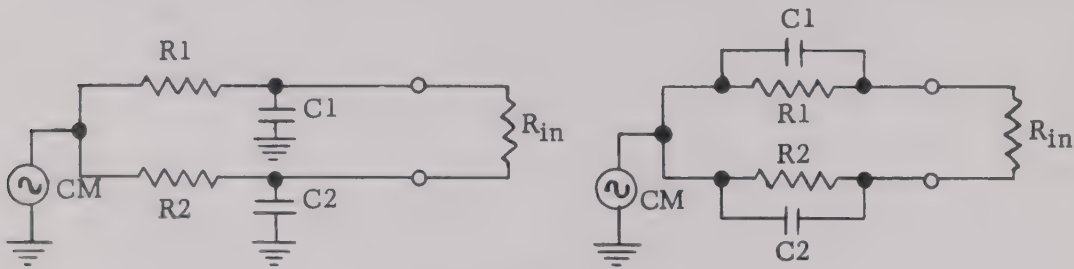


Figure 21

Without guard shield: resistance and capacitance unbalance cause a differential voltage to appear across amplifier input R_{in} .

With guard shield: resistance and capacitance unbalance can no longer cause a differential voltage to appear across amplifier input R_{in} .

5. INPUT

The input circuit of this amplifier includes a four-position function switch (CAL-ZERO-V/CM-MV/MM) and a transistor modulator consisting of Q14, Q15, Q16, Q17 and transformer T2.

The function switch operates as a balanced attenuator, offering two primary ranges of sensitivity. Signals applied to the switch through terminal E of the front panel INPUT connector J1 are fed to the emitters of Q16 and Q17 of the modulator; signals applied to terminal F of J1 are fed to the emitters of Q14 and Q15.

The modulator transistors are driven by the excitation voltage supplied by the oscillator circuit, and coupled to the bases of the transistors through transformer T2. The modulator reverses the polarity of the input signal 2400 times per second. The resulting output is a 1200-cycle square-wave signal applied to the input transformer T3 which couples the signal to the first stage a-c amplifier.

In the CAL position, the emitters of Q16 and Q17 are removed from the input signal and instead connect to a 10 millivolt d-c calibration voltage derived from calibration cell BT-1 and resistors R47, R48 for amplifier gain adjustments.

The ZERO position of the function switch ties the emitters of the modulator transistors together so that a reference or baseline may be established with the POSITION control.

6. INPUT AMPLIFIER

The two-stage input amplifier consists of transistors Q1 and Q2 and associated components. The input signal is applied to the base of Q1; the output signal from the collector of Q1 is direct-coupled to the base of Q2. A negative voltage feedback loop between the collector of Q2 and the emitter of Q1 stabilizes the a-c gain of the circuit. Blocking capacitors C3-C6 prevent changes in feedback from disturbing d-c voltage conditions of the two stages.

7. GAIN AND RANGE CONTROLS

The GAIN (sensitivity) and RANGE (attenuator) control circuits are physically located on the front panel of the recorder.

- a. The GAIN control is effective for all positions of the RANGE switch. Moving this control changes the amount of signal voltage fed from the output of Q2 to the input of Q3.
- b. The RANGE switch is divided into two circuits. In the .5, 1, and 2 positions, the change in overall gain required for attenuation is provided by varying the amount of feedback in the loop between Q2 and Q1. In the 5, 10, and 20 positions, the change in overall gain required for attenuation is provided by varying the amount of feedback in the loop between the collector of Q5 and the base of Q3.

8. THREE-STAGE AMPLIFIER

The three-stage amplifier section Q3, Q4, and Q5 amplifies the signal from the input amplifier Q1-Q2 and drives the demodulator transformer T1. This direct-coupled transistor amplifier includes the following special features:

- a. The input signal to Q3 includes two components; the (nominally) square-wave component from Q2, and the sine-wave component from the POSITION control R60. Note that either component may be at 0° or 180° phase relation to the a-c voltage from the reference source; the phase relation is interpreted by later circuits to provide an up-scale or down-scale deflection by the galvanometer writing arm.
- b. The amplifier includes a d-c negative voltage feedback loop which is connected from the emitter of Q5 back to the emitter of Q3. The function of this loop is to stabilize the d-c operating voltages of this section of the amplifier.
- c. The amplifier also includes an a-c feedback loop which is connected from the collector of Q5 back to the base of Q3. The function of this loop is to stabilize the signal gain of the amplifier against changes in component characteristics, supply voltages, etc.

9. POSITION CONTROL

The POSITION control is physically located on the front panel of the recorder. Electrically it is located across the ten-volt a-c reference line which also drives the modulator transistors. The voltage from this potentiometer is zero near the mid-point of the control, rises to a maximum at one extreme of the control, and to a similar maximum but 180° removed, at the other extreme. This voltage adds to the signal voltage applied to Q3 to give an output component from the demodulator for positioning the galvanometer writing arms.

10. DEMODULATOR AND FILTER

The demodulator, which includes transistors Q6 and Q7, center-tapped transformer T1, and the input capacitor of the filter, is a full-wave, phase-sensitive, synchronous peak detector. Circuit operation is shown in Figure 22.

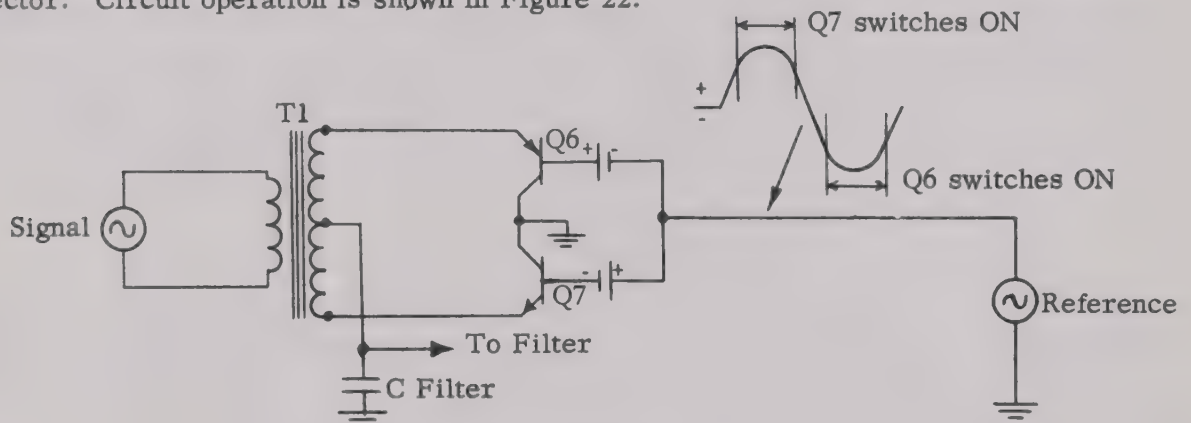


Figure 22

With no signal or reference applied, transistors Q6 and Q7 remain off and appear as a pair of open switches because of the reverse bias applied to each transistor. (The bias is shown here as a battery; the actual biasing voltage is taken from the positive and negative regulated supplies through a resistance network).

With a reference only applied, Q6 and Q7 turn on and off alternately, and approximate a pair of perfect switches which open and close in synchronism with the reference voltage. The "ON" period occurs about the peak of the positive (Q7) and negative (Q6) reference voltage waveform. An essentially perfect switching characteristic is obtained because (1) the voltage interval between transistor-OFF and transistor-ON corresponds to a small time interval, and because (2) the emitter-collector circuit being switched has an extremely high "OFF" impedance (provided by the reverse bias) and an extremely low "ON" impedance (because of the common-collector transistor circuit).

10. DEMODULATOR AND FILTER (Continued)

If a signal is now applied to the demodulator, in-phase or 180° out-of-phase with the reference, then one transistor or the other will contribute the larger amount of output. This results in a net d-c output, plus ripple components, where the d-c component has an amplitude proportional to the amplitude of the signal, and a polarity which represents the phasing between signal and reference. If, on the other hand, the signal should be at a time quadrature with the reference, then the two transistors contribute equally to the output, resulting in ripple components only, with no net d-c output. If an in-phase and a quadrature signal are present at the same time, the demodulator will respond to the in-phase component and almost completely ignore the quadrature component.

The filter which follows the demodulator is a conventional low-pass R-C filter with output to the limiter circuit, front panel MONITOR OUTPUT jack and to the input of the driver amplifier (Q10).

11. LIMITER

Output signals from the demodulator are fed to the MONITOR OUTPUT jack and to the limiter stage. The MONITOR OUTPUT jack provides a convenient means for observing the signal waveform on an oscilloscope. The source resistance at this point is 10,000 ohms. A load resistance of 1 megohm will change the calibration of the recorder by 1%. Lower load resistances will require recalibration. Approximately 40 millivolts/millimeter of deflection is available.

The limiter consists of transistors Q8, Q9 and associated components. The transistors are connected in a complementary circuit, with the input signal supplied to the emitters, the collectors grounded and the operating bias on the bases taken from the regulated + and -12 volt supplies through a resistance network. The bias voltage acts as a reference against which the signal voltage is compared. When the level of the input signal exceeds the reference voltage, in either a positive or negative direction, the appropriate transistor effectively becomes a low resistance and clamps the signal at the level set by the reference voltage. This reference voltage is selected to limit writing arm excursions to approximately 115% of full scale.

12. DUAL AMPLIFIER

The signal from the limiter is fed to the dual amplifier which includes transistors Q10, Q11 and associated components. Transistors Q10 and Q11 may be considered as one stage having two inputs and a single output.

12. DUAL AMPLIFIER (Continued)

- a. The first input signal originates as the output from the limiter; this signal is applied to emitter-follower Q10. The output from this transistor is taken from the emitter and fed to Q11 as a signal input.
- b. The second input originates as a feedback voltage from the galvanometer and includes both current and velocity feedback components.

The output signal is taken from the collector of Q11. This output includes three components of interest:

- c. The signal, originally supplied to the base of Q10, which represents the input signal to the amplifier.
- d. The current feedback signal, originating as the voltage developed across the series resistor R27 by the drive current through the signal winding of the galvanometer.
- e. The velocity feedback component generated in the feedback winding of the galvanometer coil by its motion through the magnetic field.

Note that Q11 is a part of the overall feedback loop which includes the transistors which follow it in sequence of signal flow, and the entire electro-mechanical vibrating system of the galvanometer.

13. DC AMPLIFIER AND OUTPUT STAGE

DC amplifier Q12 and Q13 is a conventional two-stage transistor amplifier. Input (from Q11) is applied to the base of Q12. Output is taken from both the emitter and collector of Q13. These two outputs are of opposite phase and are of different amplitudes so as to properly drive the output stage Q18 and Q19 which follows.

The base of Q18 is driven from the collector of Q13, and the base of Q19 is driven from the emitter of Q13. Output from this amplifier (Q18-Q19) feeds the single-ended driving section of the galvanometer coil.

14. GALVANOMETER

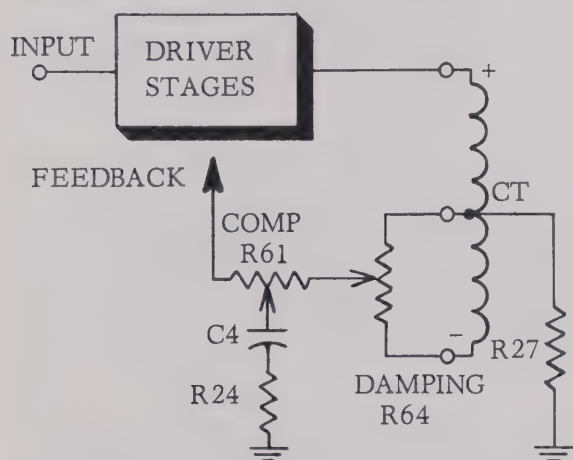
The recording galvanometer used in this instrument is similar to the classic D'Arsonval movement, used in most d-c meters. However, it differs in several important particulars. First, in order to operate at high writing speeds, an extremely stiff suspension is required to provide sufficient restoring force to the writing arm.

14. GALVANOMETER (Continued)

Second, in order to generate the forces necessary to operate with such a stiff suspension, the coil is many times larger and heavier than comparable elements of a conventional moving coil meter.

Third, because it requires large forces to move the heavy coil, the magnetic structure is of tremendous size and strength by comparison with other D'Arsonval movements.

Finally, to provide the required galvanometer damping, the coil is constructed with two windings; an inside winding which carries the currents to drive the coil, and an outside winding which generates a feedback voltage which is returned to the driver amplifier for damping.



Note: the upper portion of the coil between + and CT carries the current which drives the coil into motion. The lower portion of the coil between CT and - generates a voltage proportional to the instantaneous velocity of the coil. (The a-c component induced by the transformer action of these coils may be ignored.)

Figure 23

Galvanometer damping may be achieved by two methods: mechanical or electrical. Analysis of mechanical damping shows that it is equivalent to applying a force to the coil which is proportional to the instantaneous velocity of the coil but in direct opposition to that velocity. A mechanical device could be designed to provide any degree of damping; however, it would be difficult to adjust and maintain.

Since mechanical damping is impractical, this galvanometer uses electrical means to damp coil motion. Electrical damping requires an electrical signal, proportional to the instantaneous velocity of the coil, which is applied to the amplifier so as to oppose the velocity. The velocity voltage generated by the coil is used for this purpose.

The galvanometer and the driver amplifier are included within one feedback loop. The feedback voltage contains two components:

- a. Current feedback component, originating as the voltage developed across the series resistor R27 by the drive current through the signal winding of the galvanometer.

14. GALVANOMETER (Continued)

- b. Velocity feedback component, generated in the feedback winding of the galvanometer coil by its motion through the magnetic field. This voltage is proportional to the instantaneous velocity of the coil.

These feedback voltages are returned to the driver amplifier with such an electrical phasing as to oppose the signals which cause the galvanometer to move.

The function of the current feedback component is to keep the current through the signal winding of the coil independent of temperature changes in the galvanometer or drive circuit.

The function of the velocity feedback component is to allow galvanometer damping adjustments by electrical means. For best operation, galvanometer damping is adjusted to simulate 100% of critical. At this value the writing arm will reach its final stable value in a minimum of time in this circuit.

In this combination of driver amplifier and galvanometer, the DAMPING control R64, located in the feedback loop from the galvanometer, is adjusted so that the largest part of the damping is supplied by the signal generated in the velocity coil of the galvanometer. Both feedback components are adjusted by the COMPENSATION control R61 to complement the high frequency roll-off characteristics of the galvanometer. The latter adjustment serves to extend the response of the system beyond that of the galvanometer alone.

A smaller additional amount of damping is supplied by the coil frame of the galvanometer. This frame forms a complete closed-loop circuit, equivalent to a low-resistance, one-turn, short-circuited winding on the coil frame. The forces developed in this frame are proportional to the coil velocity, and are in such a direction as to reduce the coil velocity. This is exactly the relationship needed to damp coil motion.

15. POWER SUPPLY

The power supply consists of a transformer with a single low voltage, high current secondary winding, using a dual rectifier and filter network to provide output voltages which are equal in magnitude but of opposite polarity. These voltages are supplied to the driver and power output stages of the amplifier, and to the voltage regulating circuit which provides stable voltages to critical circuits in the amplifier.

16. VOLTAGE REGULATOR AND OSCILLATOR

Two separate voltage regulating circuits are mounted on plug-in board Model 320-100-C24. These are conventional series regulating circuits. In the positive supply, regulator transistor Q20 is in series with the current flowing through the load. Electrically, the regulator acts as a voltage dropping resistance because there is current flowing through it and a voltage drop across it. The effective resistance is controlled by changes in its base to emitter voltage. This is the basic principle of voltage regulation.

The regulator tries to keep the output voltage constant, independent of any change in the load current or of changes in the rectified d-c voltage from the rectifiers. A portion of the output voltage will appear at the base of control amplifier Q21 (the emitter of which is referenced by Zener diode CR11), and cause an amplified change of voltage to appear at its collector. Because the collector of Q21 is connected directly to the base of Q20, there will be a change in the base to emitter voltage of Q20 which changes the voltage drop across that transistor so as to oppose the original change in output voltage. Output from this circuit is adjusted to +12 volts by R68.

Operation of the negative regulated supply is similar with exception of the reference voltage for the control amplifier. This voltage is taken from the +12 volt supply. In this way, adjusting the +12 volt supply with potentiometer R68 simultaneously sets the -12 volt regulated supply.

Some instruments use a slightly different regulating circuit, however, operation is essentially the same. Potentiometer R68 is located in the negative regulating circuit and adjusting this control for -12 volts will simultaneously set the positive regulated supply to +12 volts. This regulator plug-in board is identified as assembly 320-100-C12. (See Paragraph 11, Maintenance Section).

A push-pull oscillator circuit, consisting of Q24, Q25 and associated components is also mounted on the regulator board. The operating frequency of this circuit is 1200 cycles. The output from the oscillator is supplied to the modulator, position control, and demodulator circuits.

17. TROUBLE SHOOTING HINTS

Trouble shooting procedures for the Model 320 are in most respects similar to those used on any electronic equipment. The technician will find that this instrument readily lends itself to the substitution method of locating defects due to the many plug-in assemblies and components which may be inter-changed from channel to channel. This is particularly helpful in locating defects which are confined to a single channel.

17. TROUBLE SHOOTING HINTS (Continued)**Using an ohmmeter:**

When checking for open circuits on any of the amplifier assemblies, be sure to remove the transistors associated with that circuit before making the check. If possible, remove the entire printed wire assembly if it is of the plug-in type. Never use an ohmmeter to check transistors as the voltage applied may "punch through" and consequently permanently damage the transistors. When making checks of precision resistors, use a good electronic meter of 3% full scale accuracy.

Single-Channel Defects:

Single-channel defects are readily isolated by the substitution method. Since both channels use identical plug-in components (i. e. transistors, batteries, etc.) simply interchange components from the channel which is working to the faulty channel.

Transistors: All transistors may be interchanged from channel to channel. Q10 - Q11, Q14 - Q17 (matched pairs) and Q1 - Q12 may only be replaced with their counter-parts in the working channel. Before changing transistors, be sure to turn the recorder off.

Batteries: Calibration batteries are the same for both channels. If both batteries are suspected to be faulty, replace with fresh batteries.

Galvanometer: To check a suspected galvanometer, simply interchange galvanometer leads on the terminal block at the top of the galvanometer. Be sure to note the color code of the leads.

Checking voltages: When making voltage checks on any part of the amplifiers, use a voltmeter of at least 10,000 ohms-per-volt resistance. To set the + and - supply voltages (12 volt), refer to Paragraph 13 of Section III.

Stylus Heat: Insufficient stylus heat may be caused by any one of the following factors:

Carbon deposit from the slider arm of the stylus heat potentiometer.

Carefully clean the wire surface with non-toxic cleaning fluid.

Poor contact at the writing arm clamp.

Remove the writing arm, clean the contact surface and re-clamp securely.

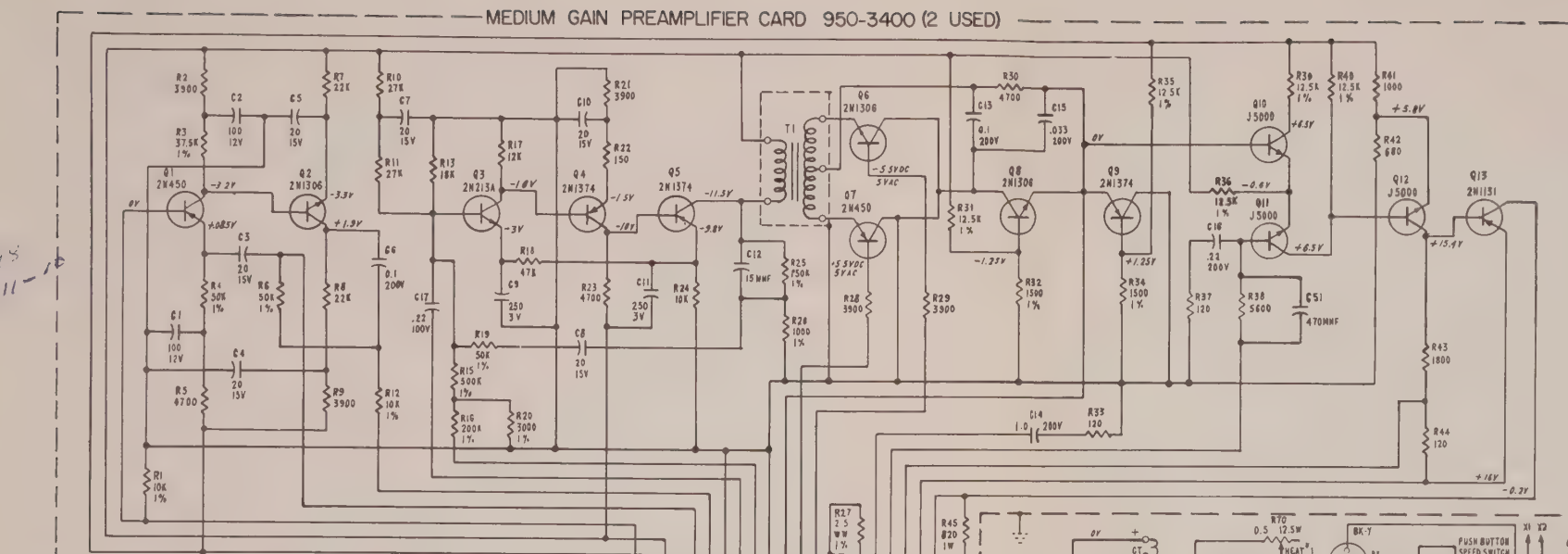
Open stylus ribbon.

Replace with new writing arm.

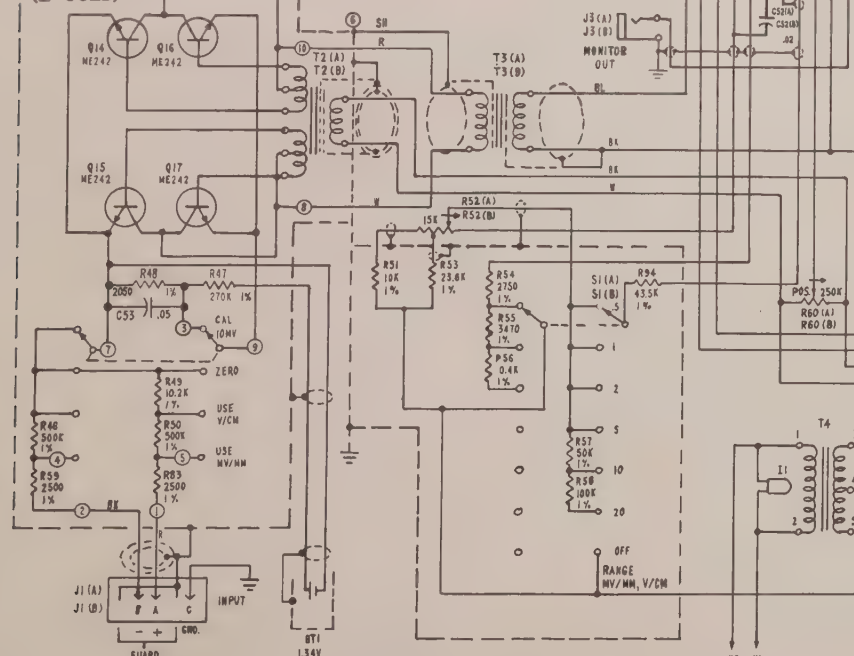
Loose heater leads at galvanometer mounting block.

Tighten all terminal screws securely.

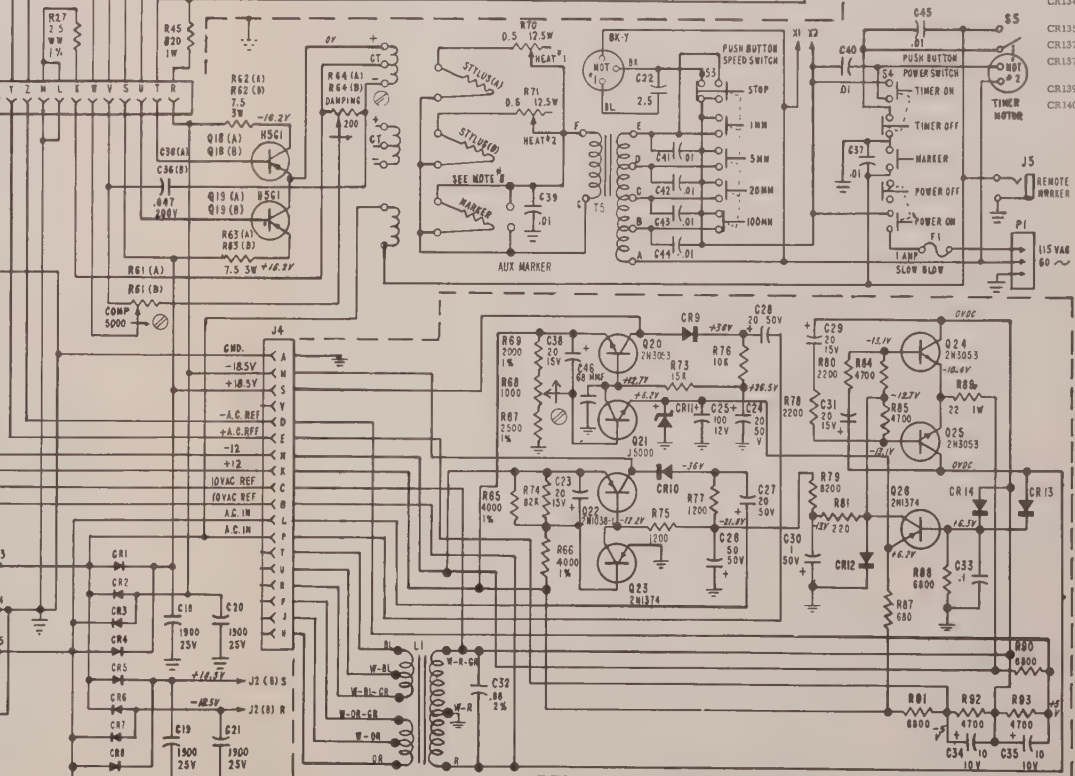
MEDIUM GAIN PREAMPLIFIER CARD 950-3400 (2 USED)



PRINTED BOARD 320-100-C30 (2 USED)



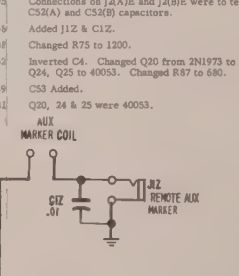
ATTENUATOR SWITCH ASSEMBLY 320-100-C3 (2 USED)



REGULATOR CARD 321-100-C10

CHANGES

- CR10775 Note 5 revised. Note 8 added. R72, R82, R66 & C30 deleted. R49 was 10.4K. R60 was 3750. CR15 & CR16 added. TM 1 removed. Shield connections changed. C39, C40, C41, C42, C43, C44 & C45 added. 5/25/60
- CR10846 Q6 was 2N169. 6/16/60
- CR10865 C46 (A and B) added, Q2 added to Note 5. 6/17/60
- CR10982 Deleted C46 (A and B). 8/4/60
- CR11077 R16 was 250K ± 1%. 10/6/60
- CR11080 Deleted regulator card assembly 320-100-C12. Added 320-100-C34 to replace. These two cards are interchangeable. 9/23/60
- On regulator board 320-100-C12, resistor R74 was replaced with a jumper. 10/14/60
- CR11242 Stores No. of BT1 changed to 2A-15A. Assembly No. of calibration section changed to 320-100-C30. 12/1/60
- CR11411 R70, R71 were 25W. R64A, R64B were 50 ohms. 1/31/61
- CR11433 Connections of Marker Coil and S4 changed. J5 added. 2/2/61
- CR11505 C17 was .25 mfd. 200V. 3/21/61
- CR11740 C1 and C2 were 20 mfd. 15 VDCW. R48 was 2K. 8/31/61
- CR11906 J2 was 22 pin printed circuit connector. 8/31/61
- CR11919 Q14, Q15, Q16, Q17 were 2N93. R66 was 4K. R69 was 2.5K. 9/7/61
- CR11900 CR11 and CR16 were 1N429. 8/16/61
- CR12038 Parts for 50 cycle operation released. 9/14/61
- CR12066 Q2 and Q8 were 2N169. Q10, Q11, Q12 were 2N169. R25 was 135K. Q6 was 2N213A. 10/2/61
- CR12068 Q2, Q8 and Q12 were selected. 10/2/61
- CR12116 C51 is added. 11/21/61
- CR12220 C25 was 20 mfd. 15V. 12/11/61
- CR12256 R22 was 47 ohm. 2/14/62
- CR12277 Q13 was 2N158. R37 was 470 ohm. 2/14/62
- CR12782 C12 was 68 mfd. disc ceramic. 7/26/62
- CR12578 Redrawn. 4/9/63
- CR12879 Redrawn, Regulator Assembly 321-100-C10 was 320-100-C24. 9/4/62
- CR12959 Q24 and Q25 were 2N1306. 10/8/62
- CR13225 Added ground connections to J2(A)-F & J2(B)-F. 1/26/63
- CR13271 Changed location of BT1. 1/30/63
- CR13287 On Q14, 15, 16, 17 arrows reversed. Also changed S62B to 242. Termination of T3 terminals were 8(R) & 10(W). 2/9/63
- CR13495 Connections on J2(A)E and J2(B)E were to term. C. Added C52(A) and C53(B) capacitors. 5/10/63
- CR13549 Added J12 & C12. 5/14/63
- CR13706 Changed R75 to 1200. 8/5/63
- CR13752 Inverted C4. Changed Q20 from 2N1973 to 40053. Changed Q24, Q25 to 40053. Changed R67 to 680. 8/5/63
- CR13939 C53 Added. 11/19/63
- CR14081 Q20, 24 & 25 were 40053. 1/10/64



SPEED IN MM/SEC	T5-VOLTAGE-G/F
320T 320	
50 100	1.8V
25 20	1.3V
5 5	.95V
2.5 1	.75V
MOTOR OFF-STD. BY	.75V

SANBORN DUAL CHANNEL DC AMPLIFIER RECORDER MODELS 320, 320T SCHEMATIC: 320-100-C1 SUB 34

SANBORN COMPANY
WALTHAM
MARCH
CR14081

MASS.
1964
RPL-320-6

SYMBOL	DESCRIPTION	SANBORN NO.	VENDOR CODE
BT1A, B	Battery, mercury (A) 1.35V	2A-15A	(SAN)
C1	100 mfd. 12V	8C-74	NLW288(CD)
CLZ	.01 mfd. disc ceramic	8E-6	29C214A1(SPR)
C2	100 mfd. 12V	8C-74	NLW288(CD)
C3	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C4	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C5	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C6	.1 mfd. 200V	8B-66	NLW341(CD)
C7	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C8	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C9	250 mfd. 3 VDCW	8C-60	TE1065(SPR)
C10	20 mfd. 15 VDCW	8C-61	TE1157(SPR)
C11	250 mfd. 3 VDCW	8C-60	TE1065(SPR)
C12	15 mfd. ± 10%	8E-14	ED-15(ER)
C13	.1 mfd. 200V	8B-66	NLW341(CD)
C14	1.0 mfd. 200V	8B-31	ML(AST)
C15	.033 mfd. 200V	8B-118	621M(GA)
C16	2.2 mfd. 25V	8B-52	621(GA)
C17	22 mfd. .0A	8B-131	M150-224(EPC)
C18	150 mfd. 25 V	8C-45MS	KP(CD)
C19	150 mfd. 25 V	8C-45MS	KP(CD)
C20	150 mfd. 25 V	8C-45MS	KP(CD)
C21	150 mfd. 25 V	8C-45MS	KP(CD)
C22	2 mfd. 330V (with bkr.)	8C-61	TE1157(SPR)
C23	20 mfd. 15 V	8C-61	TE1157(SPR)
C24	20 mfd. 50V	8C-66	NLW341(CD)
C25	100 mfd. 12 V	8C-74	NLW288(CD)
C26	50 mfd. 50 V	8C-54	300200(SPR)
C27	20 mfd. 50 V	8C-66	NLW341(CD)
C28	20 mfd. 50 V	8C-66	NLW341(CD)
C29	20 mfd. 15 V	8C-61	TE1157(SPR)
C30	1 mfd. 50 V	8PC-15	ECPA1003(CD)
C31	30 mfd. 15 V	8C-61	TE1157(SPR)
C32	88 mfd. ± 2% 50 V	8B-123	WMF(CD)
C33	1 mfd. 100 V	8B-129	BE1A104(KIEPC)
C34	10 mfd. 10 V	8C-35	NLW256(CD)
C35	10 mfd. 10 V	8C-35	NLW256(CD)
C36A, B	.047 mfd. 20% 200V mylar	8B-58	621M(GA)
C37	.01 mfd. disc ceramic	8E-6	29C214A1(SPR)
C38	20 mfd. 15 V	8C-61	TE1157(SPR)
C39	.01 mfd. disc ceramic	8E-6	29C214A1(SPR)
thru			
C45			
C46	68 mfd.	8E-21	ED-68(ER)
C51	470 mfd.	8E-9	BC470M-51(ERC)
C52A, B	.02 mfd. disc ceramic	8E-17	ID-203(CEN)
C53	.05 mfd. 500V	8E-29	39C142A(SPR)
CR1	1N2069 diode	16A-39	1N2069(TEX)
thru			
CR10			
CR11	Zener diode	16A-21	M26-2T5(DN)
CR12	1N544 germanium diode	16A-11	1N544(SYL)
CR13	1N544 germanium diode	16A-11	1N544(SYL)
CR14	1N544 germanium diode	16A-11	1N544(SYL)
CR15	1N1514 diode	16A-44	1N1514(DIC)
CR16	Zener diode	16A-21	M26-2T5(DN)
F1	115 Vac. use 1 Amp.	26B-5MS	(BUS)
F1	230 Vac. use 1/2 Amp.	26B-29	MDL 1/2(BUS)
L1	Lamp assembly	60A-31	249-7841H-1431(DIALCO)
J1A, B	3 contact male connector	10G3-34MX	(SAN)
J1Z	Open circuit jack	10G2-22FX	41(SWI)
J2A, B	22 pin printed circuit conn.	10B2-1FX	143-022-01(AMP)
J3A, B	Miniature phone jack	10G2-22FX	41(SWI)
J4	18 pin printed ckt. conn.	10B18-1FX	143-018-01(AMP)
J5	Miniature phone jack	10G2-22FX	41(SWI)
L1	Toroidal (10MH) coil	66B-131	(TRJ)
MOT-1	Motor paper drive 50 cycle	38B-54	(SAN)
MOT-1	Motor paper drive 60 cycle	38B-37	(SAN)
MOT-2	Synchronous Motor 50 cycle	38B-21A	(SAN)
MOT-2	Synchronous Motor 60 cycle	38B-21	(SAN)
P1	Plug and cord set	10G3-33MW	(SAN)
Q1	Selected 2N450 transistor	16T-21A	(SAN)
Q2	2N1306 transistor	16T-33	(TEX)
Q3	2N213A transistor	16T-26	2N213A(SYL)
Q4	2N1374 transistor	16T-31	2N1374(TEX)
Q5	2N1374 transistor	16T-31	2N1374(TEX)
Q6	2N1306 transistor	16T-33	2N1306(TEX)

Q7	2N450 transistor	16T-21	2N450(GE)
Q8	2N1306 transistor	16T-33	2N1306(TEX)
Q9	2N1374 transistor	16T-31	2N1374(TEX)
*Q10	5000 transistor	16T-37MP	(SAN)
*Q11	5000 transistor	16T-37MP	(SAN)
Q12	5000 transistor	16T-37	(SAN)
Q13	2N1131 transistor	16T-28	SM1020(TEX)
Q14	4 matched silicon ME242	16T-56MQA	(SAN)
*Q15	4 matched silicon ME242	16T-56MQA	(SAN)
*Q16	4 matched silicon ME242	16T-56MQA	(SAN)
*Q17	4 matched silicon ME242	16T-56MQA	(SAN)
Q18A, B	HSG1 Power transistor	16T-9	(SAN)
Q19A, B	HSG1 Power transistor	16T-9	(SAN)
Q20	2N3053 transistor	16T-61	2N3053(RCA)
Q21	5000 transistor	16T-37	(SAN)
Q22	2N1038-1 transistor	16T-38	2N1038-1(TEX)
Q23	2N1374 transistor	16T-31	2N1374(TEX)
Q24	2N3053 transistor	16T-61	2N3053(RCA)
Q25	2N3053 transistor	16T-61	2N3053(RCA)
Q26	2N1374 transistor	16T-31	2N1374(TEX)

*The following transistors are matched: (Q10, Q11, Q14, Q15, Q16, Q17)

R1	10K ± 1% 1/4 W	50H-103G	N-11(WEL)
R2	3.9K ± 5% 1/2 W	50AB-39J2	EB(AB)
R3	37.5K ± 1% 1/4 W	50AB-37S-2G	N-11(WEL)
R4	50K ± 1% 1/4 W	50H-503U	N-11(WEL)
R5	4.7K ± 5% 1/2 W	50AB-47J2	EB(AB)
R6	50K ± 1% 1/4 W	50H-503G	N-11(WEL)
R7	22K ± 5% 1/2 W	50AB-22J3	EB(AB)
R8	22K ± 5% 1/2 W	50AB-22J3	EB(AB)
R9	3.9K ± 5% 1/2 W	50AB-39J2	EB(AB)
R10	27K ± 5% 1/2 W	50AB-27J2	EB(AB)
R11	27K ± 5% 1/2 W	50AB-27J3	EB(AB)
R12	10K ± 1% 1/4 W	50H-103G	N-11(WEL)
R13	18K ± 5% 1/2 W	50AB-18J3	EB(AB)
R15	.5 meg ± 1% 1/4 W	50H-504G	N-11(WEL)
R16	.2 meg ± 1% 1/4 W	50H-204G	N-11(WEL)
R17	12K ± 1% 1/2 W	50AB-12J3	EB(AB)
R18	47K ± 5% 1/2 W	50AB-47J3	EB(AB)
R19	50K ± 1% 1/4 W	50H-503G	N-11(WEL)
R20	3K ± 1% 1/4 W	50H-302G	N-11(WEL)
R21	3.9K ± 5% 1/2 W	50AB-39J2	EB(AB)
R22	150 ohm ± 5% 1/2 W	50AB-151J	EB(AB)
R23	4.7 K ± 5% 1/2 W	50AB-47J2	EB(AB)
R24	10K ± 5% 1/2 W	50AB-10J3	EB(AB)
R25	150K ± 1%	50H-154G	N-11(WEL)
R26	1K ± 1% 1/4 W	50H-102G	N-11(WEL)
R27	2.5 ohm 1% WW	54PA-60F	PW-50B(TEL)
R28	3.9K ± 5% 1/2 W	50AB-39J2	EB(AB)
R29	3.9K ± 5% 1/2 W	50AB-39J2	EB(AB)
R30	4.7K ± 5% 1/2 W	50AB-47J2	EB(AB)
R31	12.5K ± 1% 1/4 W	50H-12S-2G	N-11(WEL)
R32	1.5K ± 1% 1/4 W	50H-152G	N-11(WEL)
R33	120 ohm ± 5% 1/2 W	50AB-121J	EB(AB)
R34	1.5K ± 1% 1/4 W	50H-152G	N-11(WEL)
R35	12.5K ± 1% 1/4 W	50H-12S-2G	N-11(WEL)
R36	12.5 K ± 1% 1/4 W	50H-12S-2G	N-11(WEL)
R37	120 ohm ± 5%	50AB-121J	EB(AB)
R38	5.6K ± 5% 1/2 W	50AB-56J2	EB(AB)
R39	12.5K ± 1% 1/4 W	50H-12S-2G	N-11(WEL)
R40	12.5K ± 1% 1/4 W	50H-12S-2G	N-11(WEL)
R41	1K ± 5% 1/2 W	50AB-10J2	EB(AB)
R42	680 ohm ± 5% 1/2 W	50AB-68J1	EB(AB)
R43	1.8 K ± 5% 1/2 W	50AB-18J1	EB(AB)
R44	120 ohm ± 5% 1/2 W	50AB-121J	EB(AB)
R45	820 ohm ± 5% 1 W	50AB-82J1	EB(AB)
R46A, B	.5 meg ± 1% 1/4 W	50H-504G	N-11(WEL)
R47A, B	.27 meg 1% 1/4 W	50H-274G	N-11(WEL)
R48A, B	2050 ohm ± 1% 1/4 W	50H-205-1G	N-11(WEL)
R49A, B	10.2K ± 1% 1/4 W	50H-102-2G	N-11(WEL)
R50A, B	.5 meg 1% 1/4 W	50H-504G	N-11(WEL)
R51A, B	10K ± 1% 1/4 W	50H-103G	N-11(WEL)
R52A, B	15K gain pot.	56A-12S	47F-15K(CLA)
R53A, B	23.6 K ± 1% 1/4 W	50H-236-2G	N-11(WEL)
R54A, B	2.75K ± 1% 1/4 W	50H-275-1G	N-11(WEL)
R55A, B	3.47 K ± 1% 1/4 W	50H-347-1G	N-11(WEL)
R56A, B	10.4 K ± 1% 1/4 W	50H-104-2G	N-11(WEL)
R57A, B	50K ± 1% 1/4 W	50H-503G	N-11(WEL)
R58A, B	1.1 meg ± 1% 1/4 W	50H-104G	N-11(WEL)
R59A, B	2.5K ± 1% 1/4 W	50H-252G	N-11(WEL)
R60A, B	250K position pot.	56S-12	Series 70(CHI)
R61A, B	5K Pot.	56A-144	45(CHI)
R62A, B	7.5 ohm ± 5% 3 W	53B-7R5J	151E(SPR)
R63A, B	7.5 ohm ± 5% 3 W	53B-7R5J	151E(SPR)

R64A, B	200 ohm ohm. pot.	56A-14S	45(CTS)
R65	4.7K ± 1% 1/4 W	50H-402G	N-11(WEL)
R66	4,000 ohm ± 1%	50H-402G	N-11(WEL)
R67	2.5 K ± 1% 1/4 W	50H-252G	N-11(WEL)
R68	1K screwdriver adj. pot.	56PA-1	UPM-45(CHI)
R69	2K ± 1% 1/4 W	50H-202G	N-11(WEL)
R70	.5 ohm 12.5 W	56R-4	Model E(OHM)
R71	5 ohm 12.5 W	56R-4	Model E(OHM)
R73	15K ± 5% 1/2 W	50AB-15J3	EB(AB)
R74	82,000 ohm ± 5%	50AB-82J3	EB(AB)
R75	1200 ohm ± 5%	50AB-12J3	EB(AB)
R76	10K ± 5% 1/2 W	50AB-10J3	EB(AB)
R77	1200 ohm ± 5%	50AB-12J3	EB(AB)
R78	2.2K ± 5% 1/2 W	50AB-22J2	EB(AB)
R79	2.2K ± 5% 1/2 W	50AB-22J2	EB(AB)
R80	2.2K ± 5% 1/2 W	50AB-22J2	EB(AB)
R81	220 ohm ± 5% 1/2 W	50AB-22J1	EB(AB)
R83A, B	2.5 K ± 1% 1/4 W	50H-252G	N-11(WEL)
R84	4.7 K ± 5% 1/2 W	50AB-47J2	EB(AB)
R85	4.7 K ± 5% 1/2 W	50AB-47J2	EB(AB)
R87	680 ohm ± 5% 1/2 W	50AB-68J1	EB(AB)
R88	6.8K ± 5% 1/2 W	50AB-68J2	EB(AB)
R89	22 ohm ± 5% 1 W	51D-220J	GR(AB)
R90	6.8 K ± 5% 1/2 W	50AB-68J2	EB(AB)
R91	6.8K ± 5% 1/2 W	50AB-68J2	EB(AB)
R92	4.7K ± 5% 1/2 W	50AB-47J2	EB(AB)
R93	4.7K ± 5% 1/2 W	50AB-47J2	EB(AB)
R94A, B	43.5 K ± 1% 1/4 W	50H-43S-2G	N-11(WEL)

S1A, B	2 wafer, 7 pos. rotary	62B-101	(SAN)
S2A, B	4 pos. 2 pole lever switch	62N-12	(SAN)
S3	Push button speed switch	62P-2	(SAN)
S4	Push button power switch	62P-3	(SAN)
S5	SPDT switch	62C-6	2CMD1-2AXX(ACR)

T1	Output transformer	66B-112MS	(SAN)
T2A, B	Modulation transformer	66B-116MS	(SAN)
T3A, B	Input transformer	66B-117	(SAN)
T4	Power transformer	66B-80MS	(SAN)
T5	Stylus heat transformer	66B-115MS	(SAN)

SYMBOL	DESCRIPTION	SANBORN NO.	VENDOR CODE
CR9	1N2069 diode	16A-39	1N2069(TEX)
CR10	1N2069 diode	16A-39	1N2069(TEX)
CR11	Zener diode	16A-21	M26-2T5(ER)
CR12	Germanium diode	16A-11	1N544(SYL)
CR13	Germanium diode	16A-11	1N544(SYL)
CR14	Germanium diode	16A-11	1N544(SYL)
C23	20 mfd. 15V	8C-61	TE1157(SPR)
C24	20 mfd. 50V	8C-66	NLW341(CD)
C25	100 mfd. 12V	8C-74	NLW288(CD)
C26	50 mfd. 50V	8C-54	300200(SPR)
C27	20 mfd. 50V	8C-66	NLW341(CD)
C28	20 mfd. 50V	8C-66	NLW341(CD)
C29	20 mfd. 15V	8C-61	TE1157(SPR)
C30	1 mfd. 50V	8PC-15	ECPA1003(CD)
C31	30 mfd. 15V	8C-61	TE1157(SPR)
C32	1.75 mfd. 50V mylar	8B-116	Type WM(CD)
C33	.22 mfd. 200V mylar	8B-52	Type 621(GA)
C35	10 mfd. 10V	8C-35	NLW256(CD)
C38	20 mfd. 15V	8C-61	TE1157(SPR)
L1	Toroidal (10MH) coil	66C-5	(TRD)
Q20	2N213A transistor	16T-26	2N213A(SYL)
Q21	2N169 transistor	16T-5	2N169(GE)
Q22	2N1038 transistor	16T-35	2N1038(TEX)

Q23	2N1374 transistor		
Q24	2N213A transistor		
Q25	2N213A transistor		
Q26	2N1374 transistor		
R65	4K 1% 1/4 W		
R66	13.3K ± 1% 1/4 W		
R67	2.5K 1% 1/4 W		
R68	1K screwdriver adj. pot.		
R69	2K ± 1% 1/4 W		
R70	15K 5% 1/2 W		
R71	15 meg 5% 1/2 W		
R72	3.3K 5% 1/2 W		
R73	10K 5% 1/2 W		
R74	3.3K 5% 1/2 W		
R75	2.2K 5% 1/2 W		
R76	8.2K 5% 1/2 W		
R77	3.3K 5% 1/2 W		
R78	2.2K 5% 1/2 W		
R79	8.2K 5% 1/2 W		
R80	3.3K 5% 1/2 W		
R81	220 ohm 5% 1/2 W		
R84	4.7K 5% 1/2 W		
R85	4.7K 5% 1/2 W		
R87	680 ohm 5% 1/2 W		
R88	6.8K 5% 1/2 W		
R89	22 ohm 5% 1 W		
R90	6.8K 5% 1/2 W		
R91	6.8K 5% 1/2 W		
R92	4.7K 5% 1/2 W		
R93	4.7K 5% 1/2 W		

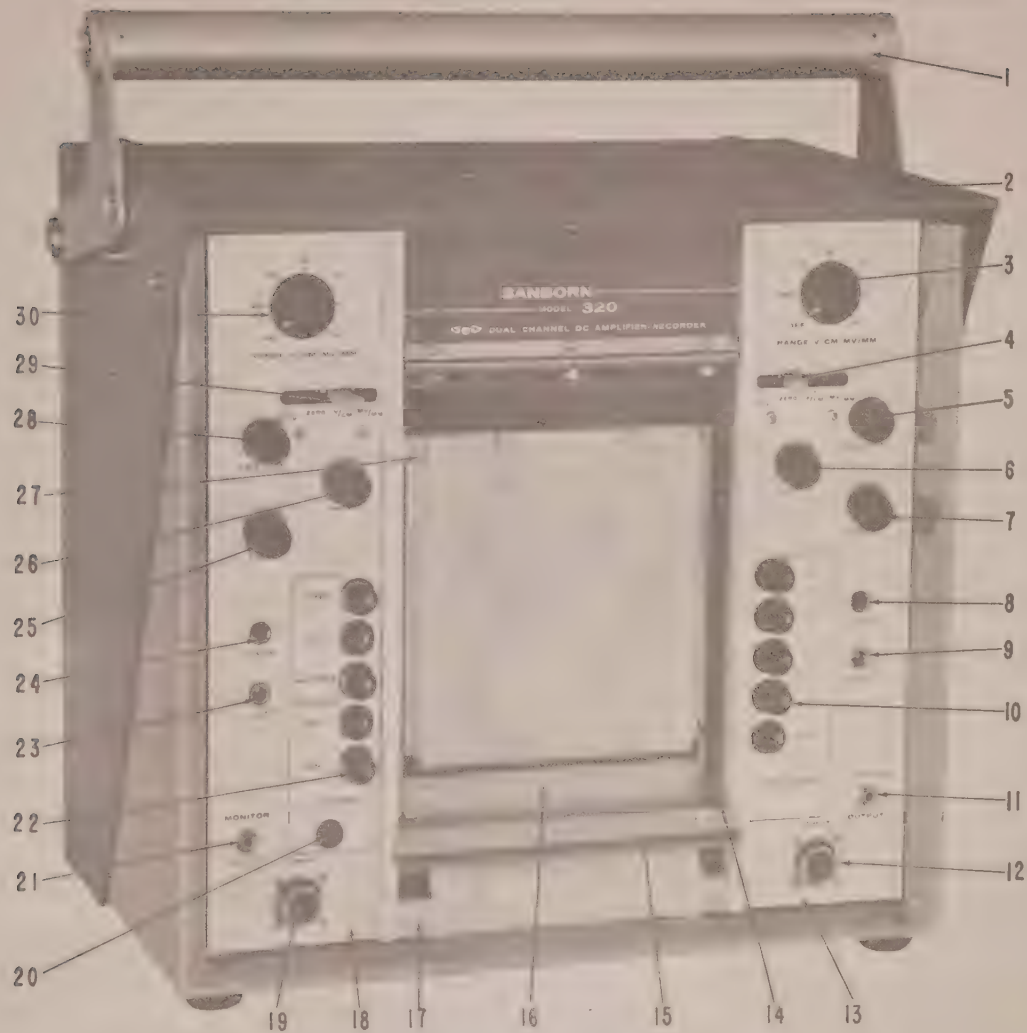


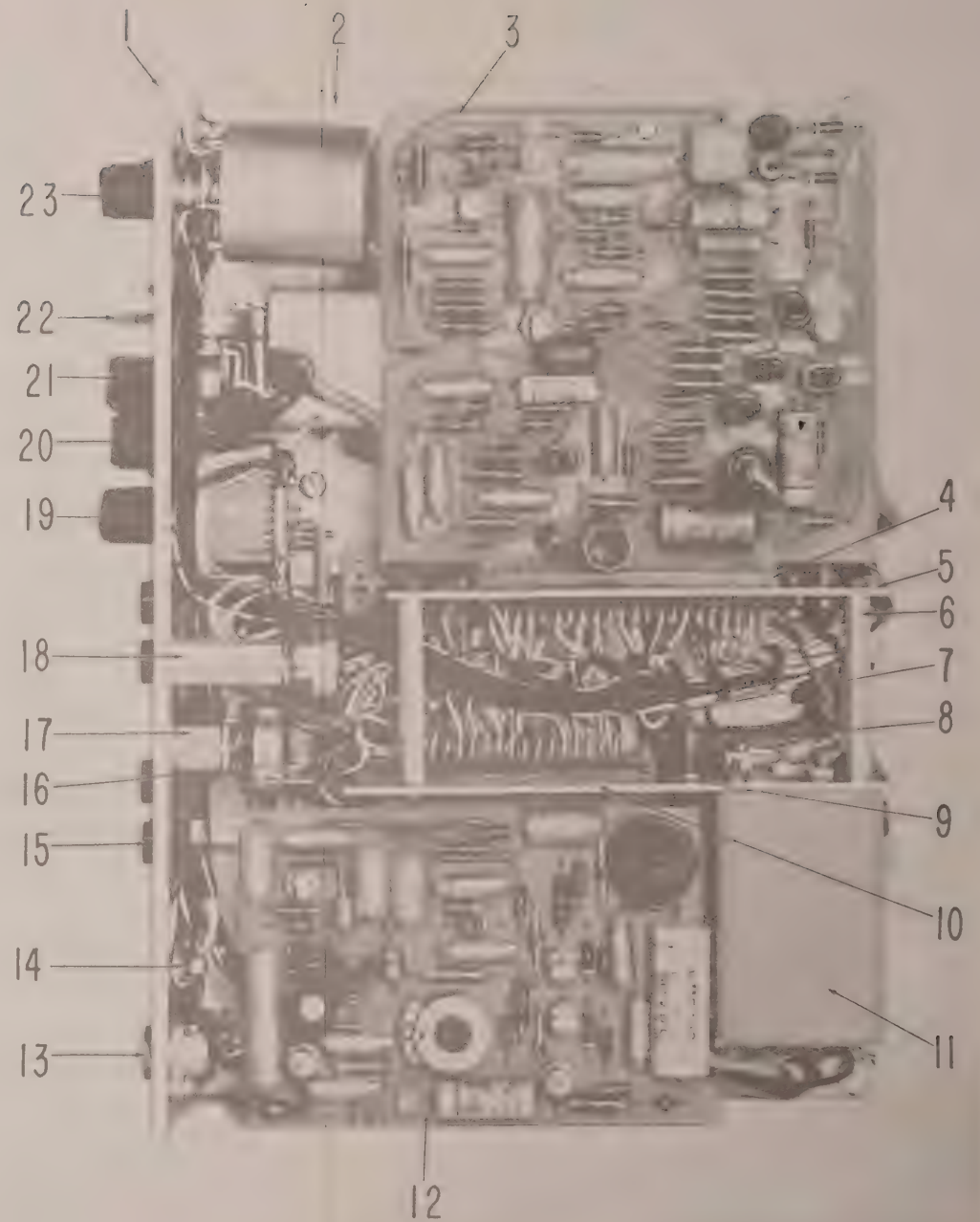
FIGURE 1. RECORDER MODEL 320, FRONT VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Handle Assembly (1)	320-1400-C2
	Handle (1)	320-1404
	Brackets (2)	320-1408
2	Carrying Case (1)	320-1400
	Carrying Case (inside) (1)	320-1401
	Carrying Case (outside) (1)	320-1402
	Latch Screw (2)	154-190
	Interlock Washer (2)	73A-10
	10-32 Hex Nut (2)	
	3/8 x 24 Hex Nut (2)	
	Retainer, Pin (2)	320-1403
	Retainer, Spring (2)	320-1405
	Pin, Handle Locking (2)	320-1406
	Screw, Handle (2)	320-1407
	Plug Buttons, 1/2" (2)	22B-11
	Plug Buttons, 3/8" (1)	22B-2
	Spring Coil (2)	37G-5
	Washer (Handle mounting) (2)	74A-375A
	Washer (Handle mounting) (2)	74A-500
	Rubber Feet (4)	77A-53
	Rubber Feet (bottom) (4)	77A-3
	3/16 x 6-32 Screw (2)	80A-632-3C
	1/2 x 6-32 Screw (4)	80A-632-8E
	1/2 x 1/4-20 Screw (4)	80A-1420-8A
	1/2 x 8-32 Sems (8)	83A-8-8B
	1/2 x 10-32 Sems (2)	83A-10-8B
3	7 Position Wafer Switch (See figure 4)	62B-101
4	Lever (S2B) Switch	62N-12
5	Pot 250K (R60B)	56S-12
6	Pot 15K (R52B)	56A-125
7	Pot .5 Ohm (R71) 12.5 W	56R-4

8	Pot 50 Ohm (R64B)	56A-145
9	Pot 5K (R61B)	56A-144
10	Switch, five button push button	62P-2
11	Phone Jack (J3B)	10G3-22FX
12	3 Contact Male Connector	10G3-34MX
13	Panel, right control (1)	320-106
	Insert right front (1)	320-104
14	Table, paper drive assy. (See figure 15)	
15	Window Assembly	
	Window, Recorder (1)	320-113
	Cover, Slide (1)	320-170
	Handle, Window (1)	320-171
	Spring, Window (1)	836-10
	Holder Latch	320-179
	Hinge, Window (1)	826-23
	Latch, Viewing Window (2)	300-107
	Spring, Viewing Plate (2)	300-115
16	Guide, Paper (1)	320-120
17	Shield Pressure Roll (1)	320-167
18	Panel, Left Control (1)	320-105
	Insert, Left Panel (1)	320-103
19	3 Contact Male Connector	10G3-34MX
20	Lamp Assembly (11) Power	60A-31
21	Phone Jack (J3A)	10G2-22FX
22	5 Button Push Switch (S4)	62P-3
23	Pot 5K (R61A)	56A-144
24	Pot 50 Ohm (R64A)	56A-145
25	Pot .5 Ohm 12.5 W (R70)	56R-4
26	Pot 15K (R52A)	56A-125
27	Table Lock (1)	320-174
	Table Lock Spring (1)	158-118
28	Pot 250K (R60A)	56S-12
29	Switch Lever (S2A)	62N-12
30	7 Position Wafer Switch (S1A) (See figure 4)	62B-101

FIGURE 2. RECORDER, MODEL 320, RIGHT SIDE VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Panel, Right Control	320-106
2	Side Plate, Right	320-108
3	Printed Circuit Board Assy See Figure 21	950-3400
4	22 Pin Printed Circuit Conn.	10B22-1FX
5	Chassis, Upper Right	320-156
	3/8 x 4-40 Sems	83A-4-4B
	Pem #4	40P-4-3
	Eyelet	20A-22
6	Spacer, Hex (4)	701-876-72
	3/8 x 6-32 Sems	83A-6-6B
7	Res. .25 Ohm 10 W Deleted	53A-R25K
8	Insulated Standoff (3)	34E-1
	1/4 x 4-40 Sems	83A-4-4B
9	18 Pin Printed Cir. Conn. (J4)	10B18-1FX
10	Chassis, Lower Right	320-157
11	Transformer (T5)	66B-115MS
	6-32 Lockwasher	73A-6
	6-32 Hex Nut	
12	Lug, Right Angle	34A-5A
	Printed Circuit Board Assy. See figure 22	321-100-C10
13	3 Pin Male Conn. (J1B)	10G3-34MX
	3/8 x 4-40 Screw	80A-440-6C
	Lockwasher #4	73A-4
	Hex Nut #4	
	Nylon Washer #4	710N-4
	Lug, Right Angle	34A-5
14	Phone Jack (J3B)	10G2-22FX
15	Switch, 5 Button Push (S3)	62P-2
	Bracket (1)	320-117
	Knob	32A-52
16	Capacitor, .047, 200V (C36B)	88-58
17	Pot 5K (R61B) Comp	56A-144
	Pot Standoff	169-135P3
	Bushing	169-134
	Lug Pot	34A-8
18	Pot 50 Ohm (R64B)	56A-145
	Pot Standoff	169-135P4
	Bushing	169-134
19	Pot .5 Ohm, 25 W (R71)	56R-4
	Lug, Pot	34A-8
	Knob 1/4 Shaft	32A-47
20	Pot 15K (R52B) Gain	56A-125
	Lug Pot	34A-8
	Knob 1/4 Shaft	32A-47
21	Pot 250K (R60B) Position	56S-12
	Knob 1/8 Shaft	32A-53
	Lug 1/4 Hole	34A-31
22	Rt. Cal. Assy. See Fig. 5	320-100-C10
	Knob, Switch Lever	32A-51
	Washer, Nylon #4	710N-4
	3/8 x 4-40 Screw	80A-440-6B
23	See Figure 23	
	Swi. Assy. (S1B)	320-100-C3
	(See figure 4)	
	Shield Can	829-1P1
	Knob, skirted	32A-54



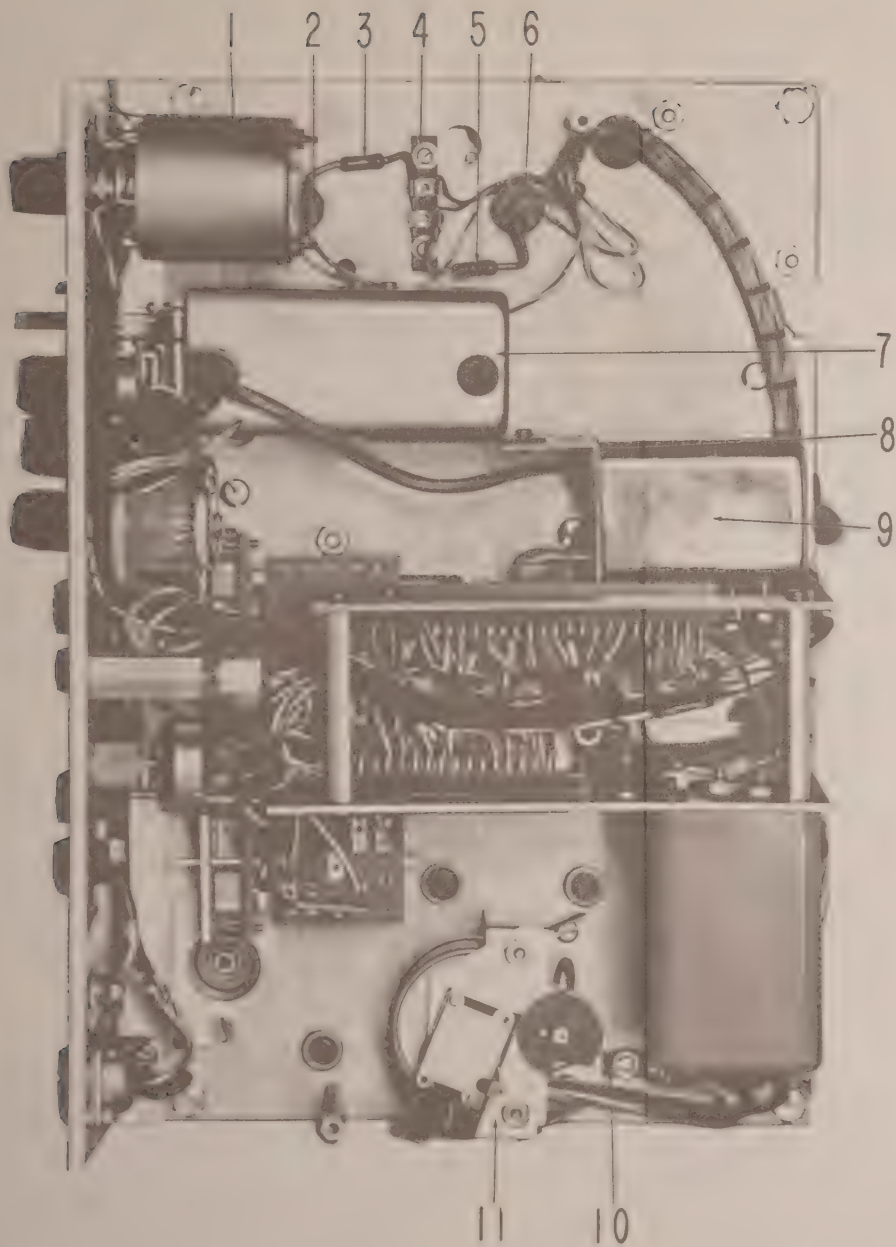


FIGURE 3. RECORDER, MODEL 320, RIGHT SIDE VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Shield Can	829-1P1
2	Trans. power HSG1 (Q18B)	16T-9
3	7.5 Ohm $\pm$ 5% 3 W (R62B)	S3B-7R5J
4	2 Contact Term. Strip (E2)	64A-5
5	7.5 Ohm $\pm$ 5% 3 W (R62B)	S3B-7R5J
6	HSG1 Transistor (Q18B)	16T-9
7	Calibration Shield Can, Assy.	320-100-C14
8	Bracket, Transformer Mounting	320-109
9	Transformer (J3B) Input	40P-4-2
	6-32 Lockwasher	66B-117
	6-32 Hex Nut	73A-6
10	Terminal Strip, 4 Con. (E1)	64C-6
11	Timer Assy 60 Cycle	152-1300B-C2P5
	Timer Assy 50 Cycle	152-1300B-C2P6
	(See Figure 6)	

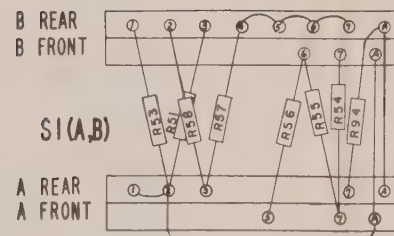


FIGURE 4. SWITCH ASSEMBLY
320-100-C3

REFERENCE NO.	DESCRIPTION	SANBORN NO.
S1	Switch, 7 Position Wafer	62B-101
R54	Resistor 2750 1/4W 1%	50H-275-1G
R55	Resistor 3470 1/4W 1%	50H-347-1G
R56	Resistor 10.4K 1/4W 1%	50H-104-2G
R57	Resistor 50K 1/4W 1%	50H-503G
R58	Resistor 100K 1/4W 1%	50H-104G
R53	Resistor 23.6K 1/4W 1%	50H-236-2G
R51	Resistor 10K 1/4W 1%	50H-103G
R94	Resistor 43.5K 1/4W 1%	50H-435-2G
	Attenuator Shield Assy.	320-100-C34

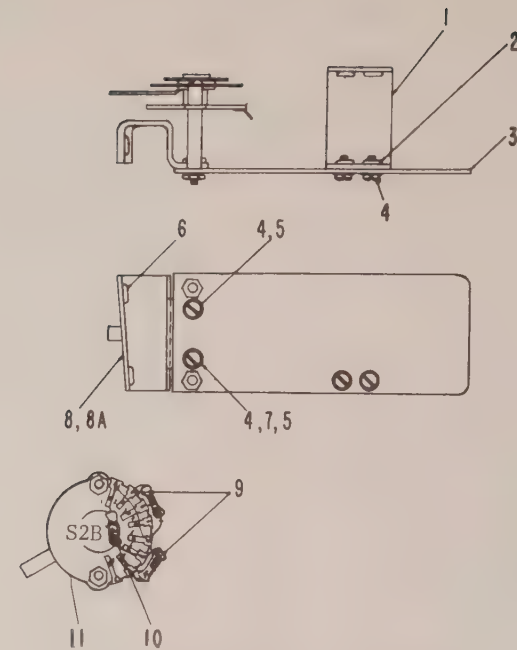


FIGURE 5. RIGHT CAL ASSEMBLY
320-100-C10

REFERENCE NO.	DESCRIPTION	SANBORN NO.
1.	Bracket, cal. Assembly, Mounting	320-150
2.	Pem No. 4-40	40P-4-2
3.	Printed Board Assy. See Fig. 23	320-100-C30
4.	Sems, No. 4-40 x 1/4 Long	83A-4-4B
5.	Hex Nut No. 4	
6.	Pem No. 4-40	40P-4-2
7.	Ground Lug Deleted	34A-5
8.	Bracket, Right CAL Assembly Mounting	320-152
8A.	Bracket, Left CAL Assembly Mounting	320-151
9.	Resistor, 500K 1/4W 1% (R48B, R50B)	50H-504G
10.	Resistor, 10.2K 1/4W 1% (R49B)	50H-102-2G
11.	Switch, Lever (S2B)	62N-12

NOTE: Left CAL Assembly, 320-100-C11, same except:
R49B becomes R49A
R46B becomes R46A
R50B becomes R50A
S2B becomes S2A

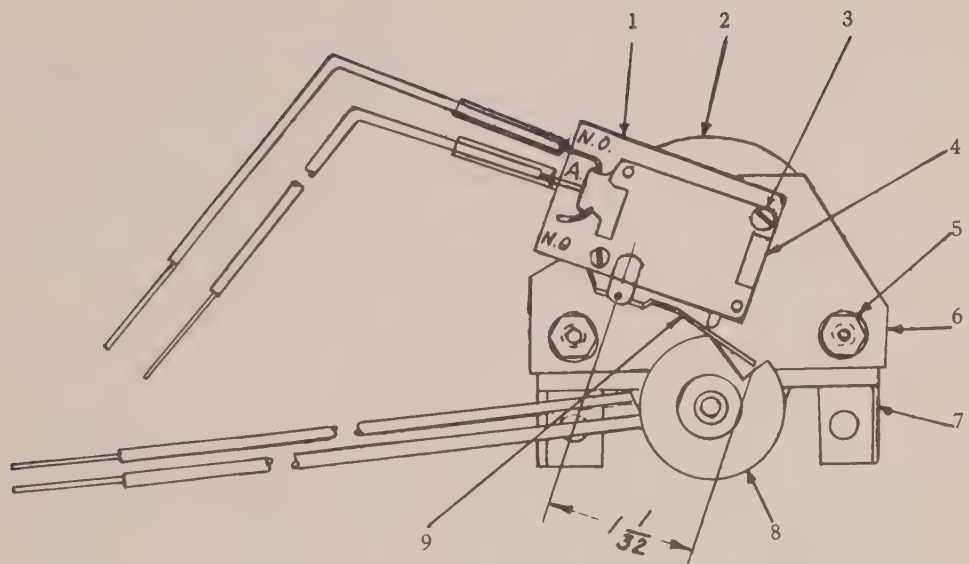


FIGURE 6. TIMER ASSEMBLY
60 CYCLE 152-1300B-C2P5
50 CYCLE 152-1300B-C2P6

REF. NO.	DESCRIPTION	SANBORN NO.
1	Power switch insulator	572-148
2	Synchronous motor (60 cycle)	38B-21
3	#2-56 x 7/16 lg. sems unit	83A-2-7B
4	SPDT coin switch	62C-6
5	#6-32 x 1/2 lg. sems unit	83A-6-8B
	#6-32 hex nut	
	Internal lock washer	73A-6
	Flat washer	74A-6L
	#6-32 pems	40P-6-2
6	Timer switch plate	152B-1303P1
7	Timer mtg. bracket	154B-1305P1
8	Timer cam assembly	152-1300B-C4
9	Micro switch actuator	62C-1A

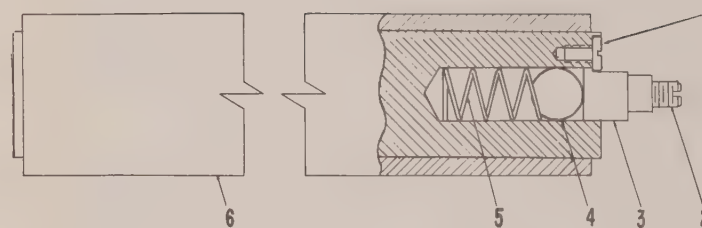


FIGURE 7. RECORDER BRAKE ROLL ASSEMBLY
320-100-C20

REFERENCE NO.	DESCRIPTION	SANBORN NO.
1.	4-40 x 3/16 Long Bnd. Hd. Sc.	80A-440-3B
2.	1/2 Set Screw Sloted Cup Point	81A-1032K
3.	Pivot, Brake Adjustment	320-138
4.	3/8 Steel Ball	6A-4
5.	Spring, Brake	151-154
6.	Brake Roll Assembly	151-100-C18P2.

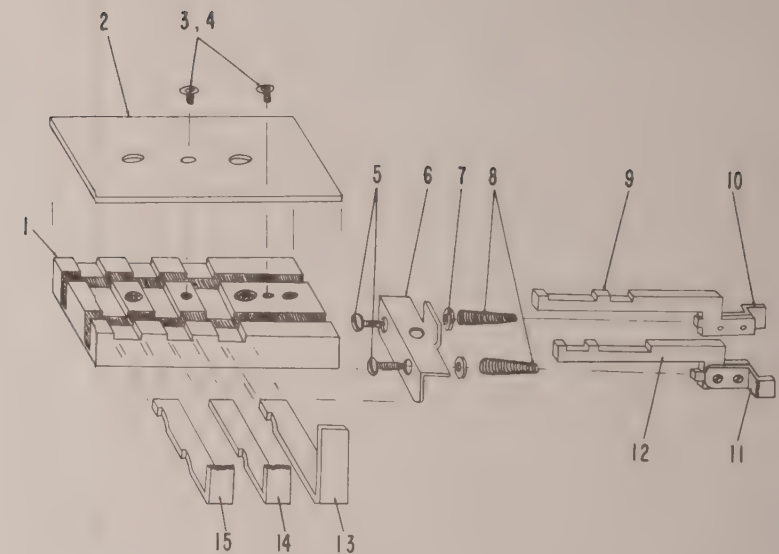


FIGURE 8. CLUTCH ACTUATOR ASSEMBLY 320-100-C27

REFERENCE NO.	DESCRIPTION	SANBORN NO.
1.	Support, Clutch Actuator	320-109
2.	Plate, Clutch Actuator Bearing	320-123
3.	4-40 x 5/16 Sems	83A-4-5B
4.	No. 4 Flat Washer	74A-4
5.	6-32 x 3/8 Sems	83A-6-6B
6.	Bracket, Actuator Spring	320-163
7.	No. 6 Hex Nut	
8.	Spring	824-33
9.	Actuator, Clutch (lower)	320-126
10.	Bracket, Actuator Adjust (lower)	320-158
11.	Bracket, Actuator Adjust (upper)	320-159
12.	Actuator, Clutch (upper)	320-127
13.	Cam (5MM)	320-130
14.	Cam (20MM)	320-129
15.	Cam (100MM)	320-128

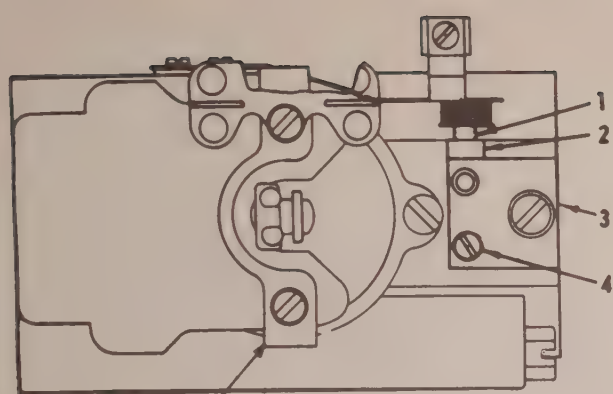


FIGURE 9. GALVANOMETER ASSEMBLY
SANBORN NUMBER 608D

REF. NO.	DESCRIPTION	SANBORN NO.
1	10-32 x 1/2 long set scr.	81D-10-8
2	Block, adjust lead marker	158-1033
3	Clamp, L.M. Post	608-108
4	2-56 x 1/4 sem	83A-2-4B
5	Galvy assy. See Figure 10	607
6	Coil & stylus holder assy.	608D-100-C3
7	Lead marker board assy.	158-1000-C10
8	Lead marker support	608-102
9	4-40 x 7/16 sem	83A-4-7B
10	4-40 x 5/16 sem	83A-4-5B
11	#4 int. lock washer	73A-4
12	Bridge	608-103

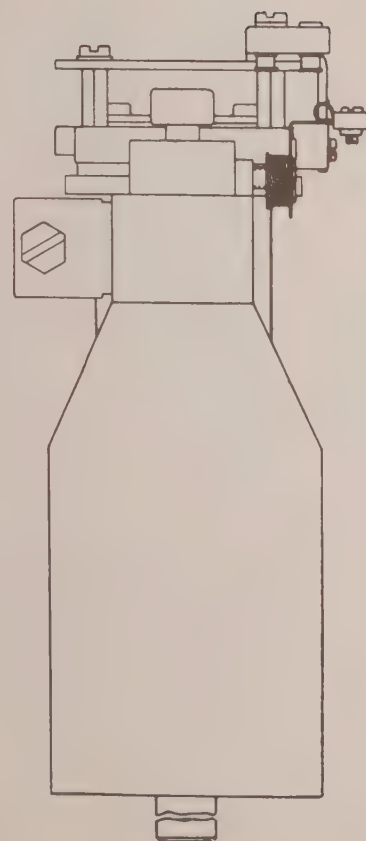
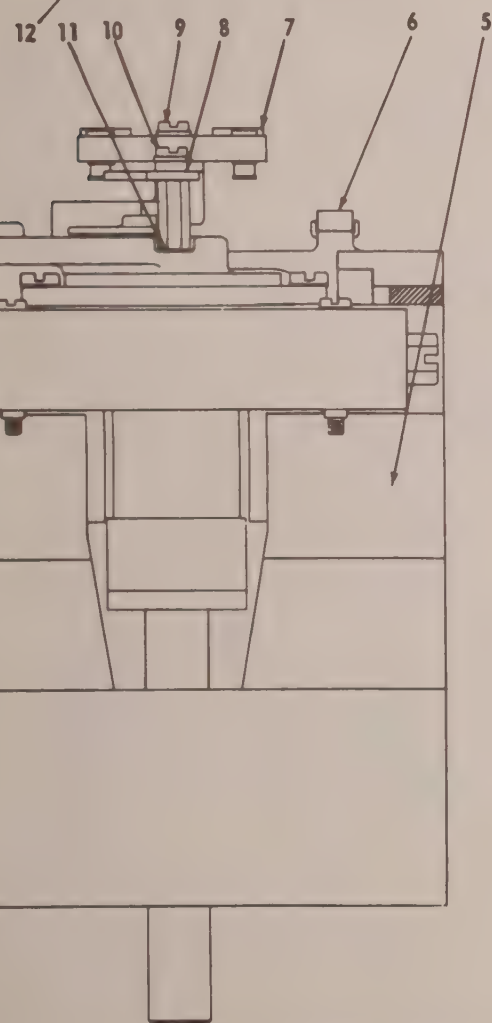


FIGURE 9. GALVANOMETER ASSEMBLY SANBORN NUMBER 608D

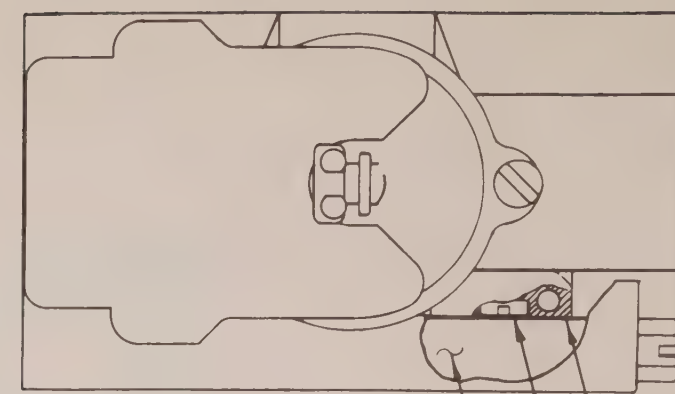


FIGURE 10. GALVANOMETER ASSEMBLY
SANBORN NUMBER 607

REF. NO.	DESCRIPTION	SANBORN NO.
1	#4-40 sems x 5/16 long	83A-4-5B
2	Shunt block	158-1005
3	Shunt step block	158-1004
4	#4-40 sems x 7/8 long	83A-4-14B
5	Cover, shunt	158-1007
6	Assembly, shunt adjustment	158-1000-C1
7	Assembly, galvy (see figure 11)	606
8	Permanent magnet assembly	151-1001
9	Galvanometer Connector Cable	10G11-1MWL

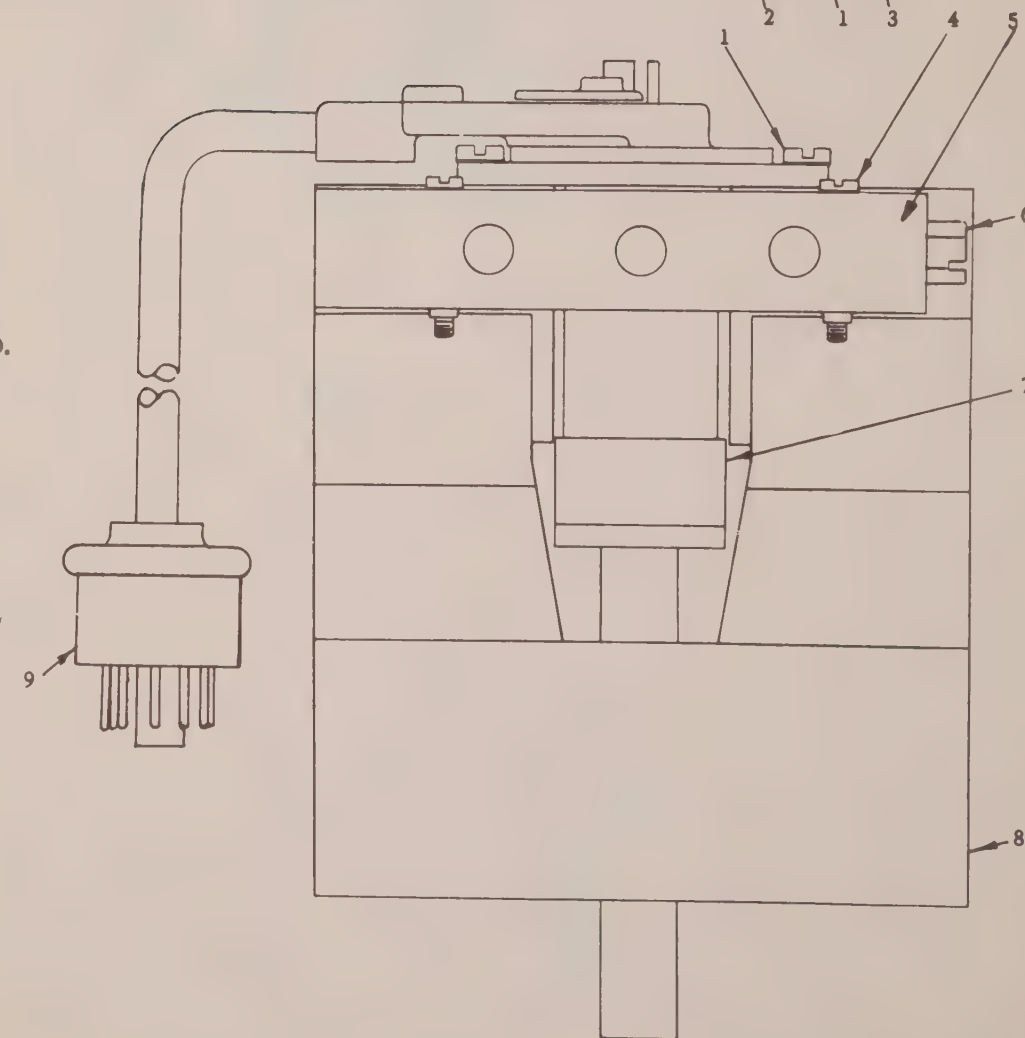


FIGURE 10. GALVANOMETER ASSEMBLY SANBORN NUMBER 607

FIGURE 11 GALVANOMETER ASSEMBLY (INSERT) 606

REFERENCE NO.	DESCRIPTION	SANBORN NO.
1.	Jumper	606-100-C11-P1
2.	4-40 x 7/16 Long Sem	83A-4-7B
3.	2-56 x 1/8 Long Sem	83A-2-2B
4.	Stop	613-106-P2
5.	Stop	613-106-P1
6.	Pigtail and Lug Assembly	606-100-C7-P3
7.	Pigtail and Lug Assembly	606-100-C7-P1
8.	Pigtail and Lug Assembly	606-100-C7-P2
9.	Jumper	607-100-C11P2

10.	4-40 x Long Machine Screw	80A-440-4B
11.	4-40 x 1/4 Long Sem	83A-4-4B
12.	Galvy Cap Assembly	606-106
13.	Plain Washer	74A-4
14.	Galvy Coil Assembly	606-100-C2
15.	8-32 x 5/16 Long Sem	83A-8-5B
16.	4-40 x 1/8 Long Allen Head	
	S.S. Cup Point	81B-4-2C
17.	Torsion Rod	606-116
18.	Galvy Cover	606-109
19.	Stylus Mounting Adapter Assembly	613-100-C7
20.	Grip ring	59C-1
21.	Center Block	572-330
22.	Sleeve Assembly	621-100A-C4
23.	Galvy Coil Housing	606-123

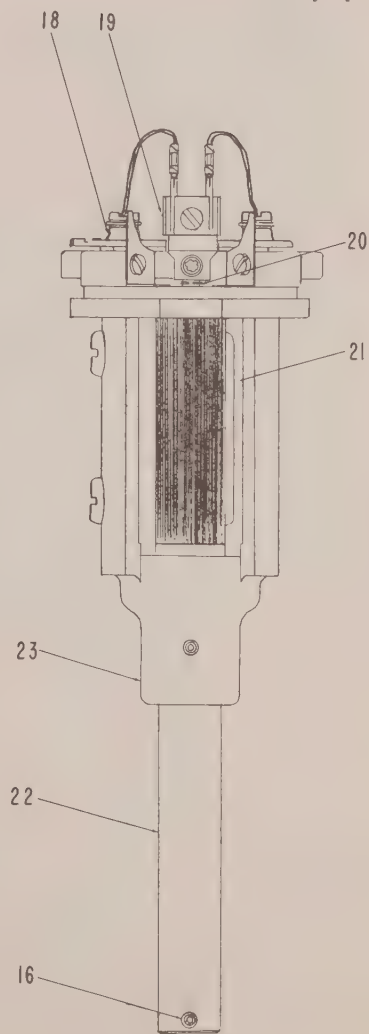
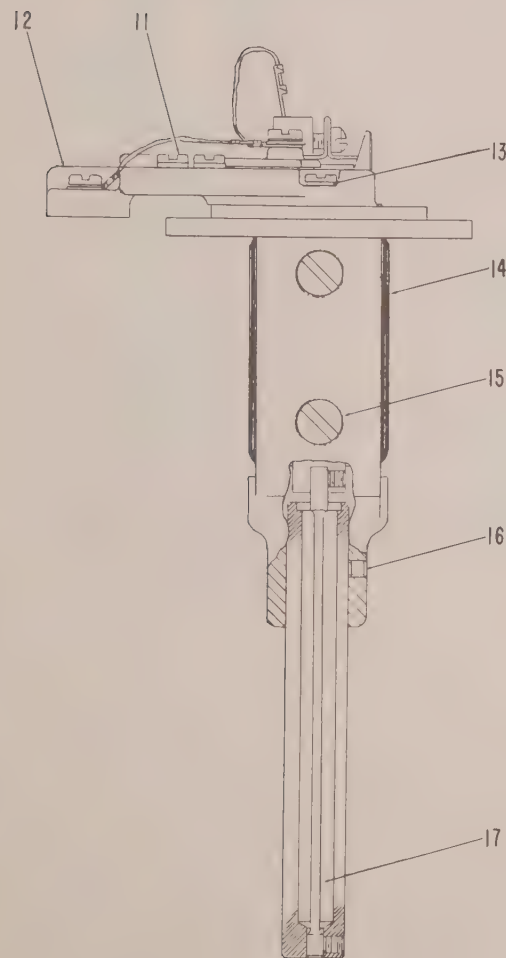
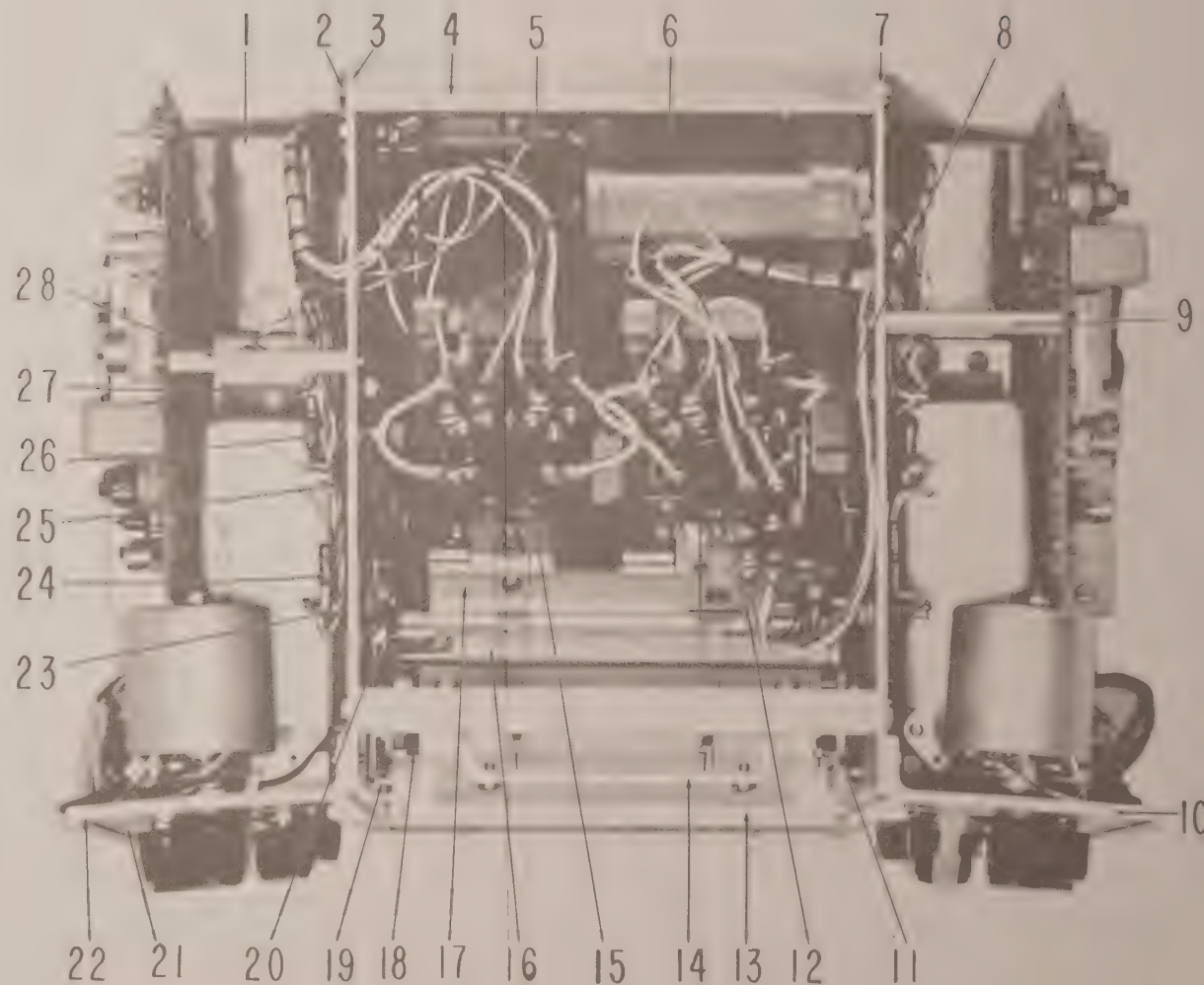


FIGURE 12. RECORDER, MODEL 320, TOP VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Transformer (T3A)	668-117
	Chassis, Upper Left	320-154
	Bkt. Transformer Mounting	320-169
	6-32 Lockwasher	73A-6
	6-32 Hex Nut	
	Hex Nut #4	
	4-40 x 3/8 Sems	83A-4-6B
	Pem #4	40P-4-3
	Eyelet	20A-22
	Pem #4	40P-4-2
2	Shoulder Screw #10	838-7
3	Side Plate, Left	320-107
4	Spacer, Side Plate	320-161
5	Galvy Mounting Plate	320-110
6	Capacitor, 2.5 Mfd, 330V(C22)	8B-117
	8-32 x 5/16 Sems	83A-8-5B
7	8-32 Hex Nut	320-108
8	Side Plate, Right	320-108
9	Clutch Actuator Assy. (See Figure 8)	320-100-C27
10	Spacer, Hex (2)	701-8T6-68
11	Panel, Right Control	320-106
12	Insert, Right Panel	320-104
13	Paper Drive Table	320-112
14	Galvy With Lead Marker (See Figure 9)	
15	Shield, Pressure Roll	320-167
16	Spring Window	836-10
17	Galvy Assy. See Figure 10	607
18	Hinge, Male	320-118
19	Hinge, Female	320-119
20	Platen	320-164
21	Table Lock	320-121
22	Spring	158-118
23	Stud, Table Lock	320-141
24	Stylus Lifter Assembly	320-144
25	Bracket Stylus Lifter	320-143
26	Link, Stylus Lifter (lg. arm)	320-145
27	Pivot, Stylus Lifter Link	320-103
28	Insert, Left Panel	320-105
29	Panel, Left Control	167-9
30	Trans, HSG1 (Q19A)	538-7R5J
31	7.5 Ohm ± 5% 3 W (R63A)	644-5
32	2 Contact Terminal Strip (E3)	538-7R5J
33	7.5 Ohm ± 5% 3 W (R62A)	167-9
34	Trans, HSG1 (Q18A)	701-8T6-68
35	Spacer, Hex	



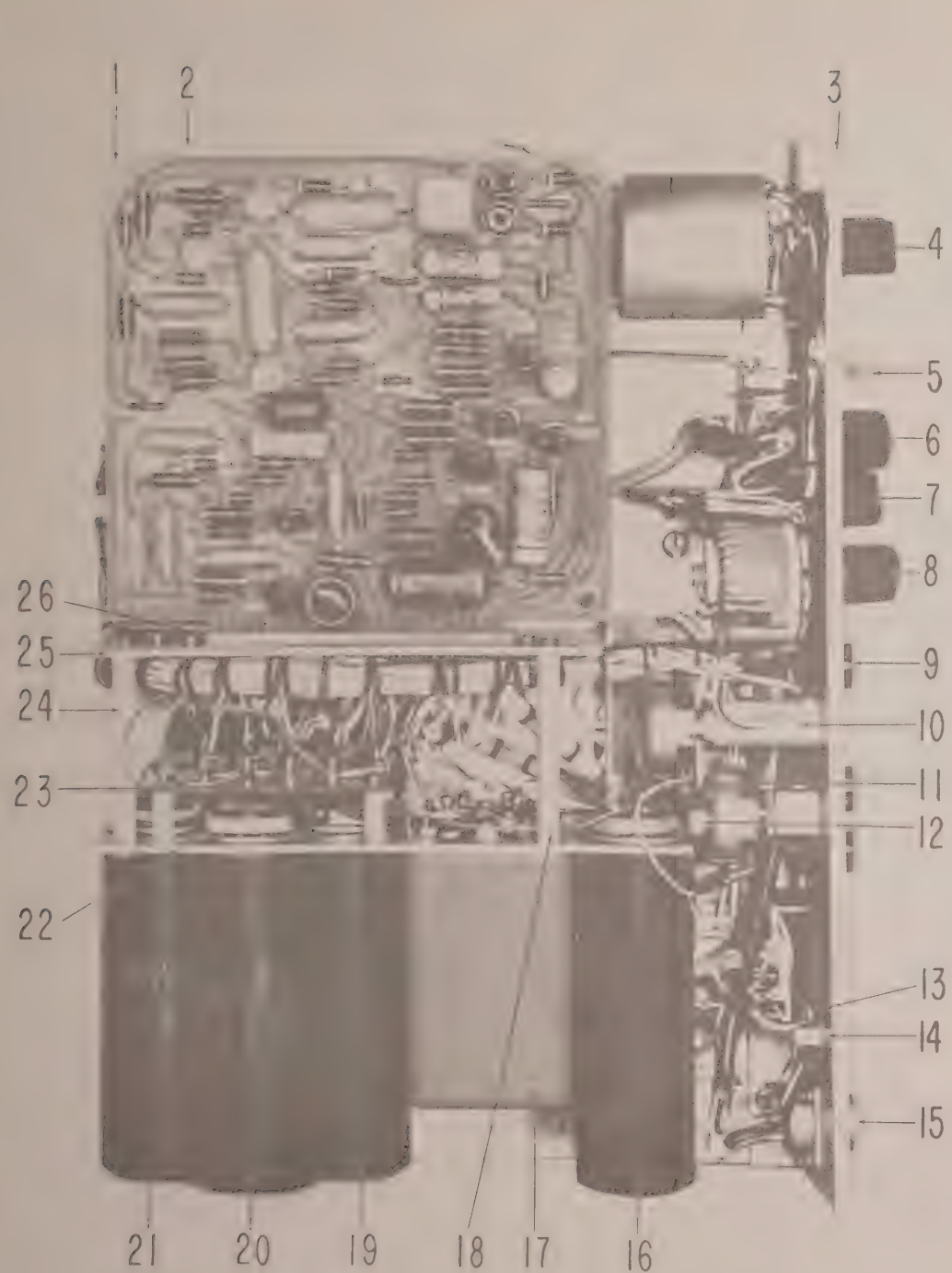


FIGURE 13. RECORDER, MODEL 320, LEFT SIDE VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Printed Circuit Board Assy. (See Figure 21)	950-3400
2	Side Plate, Left	320-107
3	Panel, Left Control	320-105
4	Switch Assy (S1A) (See Figure 4)	320-100-C3
5	Shield Can Slotted Knob Right Calibration Assy. (S2A) (See figure 5)	829-1PI 32A-54 320-100-C10
6	Knob, Switch Lever Washer, Nylon #4 Screw, 3/8 x 4-40 Calibration Card Assy. (See Figure 23)	32A-51 710N-4 80A-440-6B 320-100-C30
7	Pot, 250K (R60A) Knob, 1/8 Shaft Lug, 1/4 Hole	56S-12 32A-53 34A-31
8	Pot, 15K (R52A) Gain Lug, Pot Knob, 1/4 Shaft	56A-125 34A-8 32A-47
9	Pot, .5 Ohm 12.5 W (R70) Lug, Pot Knob, 1/4 Shaft	56R-4 34A-8 32A-47
10	Push Switch 5 Button (S4) .01 Mfd. Disc (C37) Push Button Switch Bracket Knob, Push Switch	62P-3 8E-6 320-117 32A-52
11	Pot, 200 Ohm (R64A) Pot Standoff Bushing	56A-145 169-135P4 169-134
12	Pot, 5K (R61A) Pot Standoff Bushing	56A-144 169-135P3 169-134
13	Lug, Pot .047, 200V Cap. (C36A)	34A-8 8B-58
14	Lamp Assembly (I1)	60A-31
15	Phone Jack, (J3A) 3 Pin Male Connector (J1A) 3/8 x 4-40 Screw Lockwasher #4 Hex Nut #4 Nylon Washer #4	10G3-22FX 10G3-34MX 80A-440-6C 73A-4 710N-4 34A-5
16	Lug, Right Angle 1900 Mfd, 25V Cap. (C21) Transformer (T4) Lug, Right Angle	8C-45MS 66B-80MS 34A-5A
17	Spacer 6-32 Lockwasher 6-32 Hex Nut	701-8T6-72 73A-6
18	1900 Mfd, 25 V (C19) 1900 Mfd, 25 V (C20) 1900 Mfd, 25 V (C18)	8C-45MS 8C-45MS 8C-45MS
19	Bracket, Lower Left Side Diode Mfg. Board Assy. (E4) (See figure 19)	320-155 320-100-C2
20	1/4 x 4-40 Sems	83A-4-40
21	Spacer 3/8 x 6-32 Sems	701-8T6-72 83A-6-6B
22	Chassis, Upper Left Side	320-154
23	22 Pin Printed Circuit (J2A)	10B22-1FX

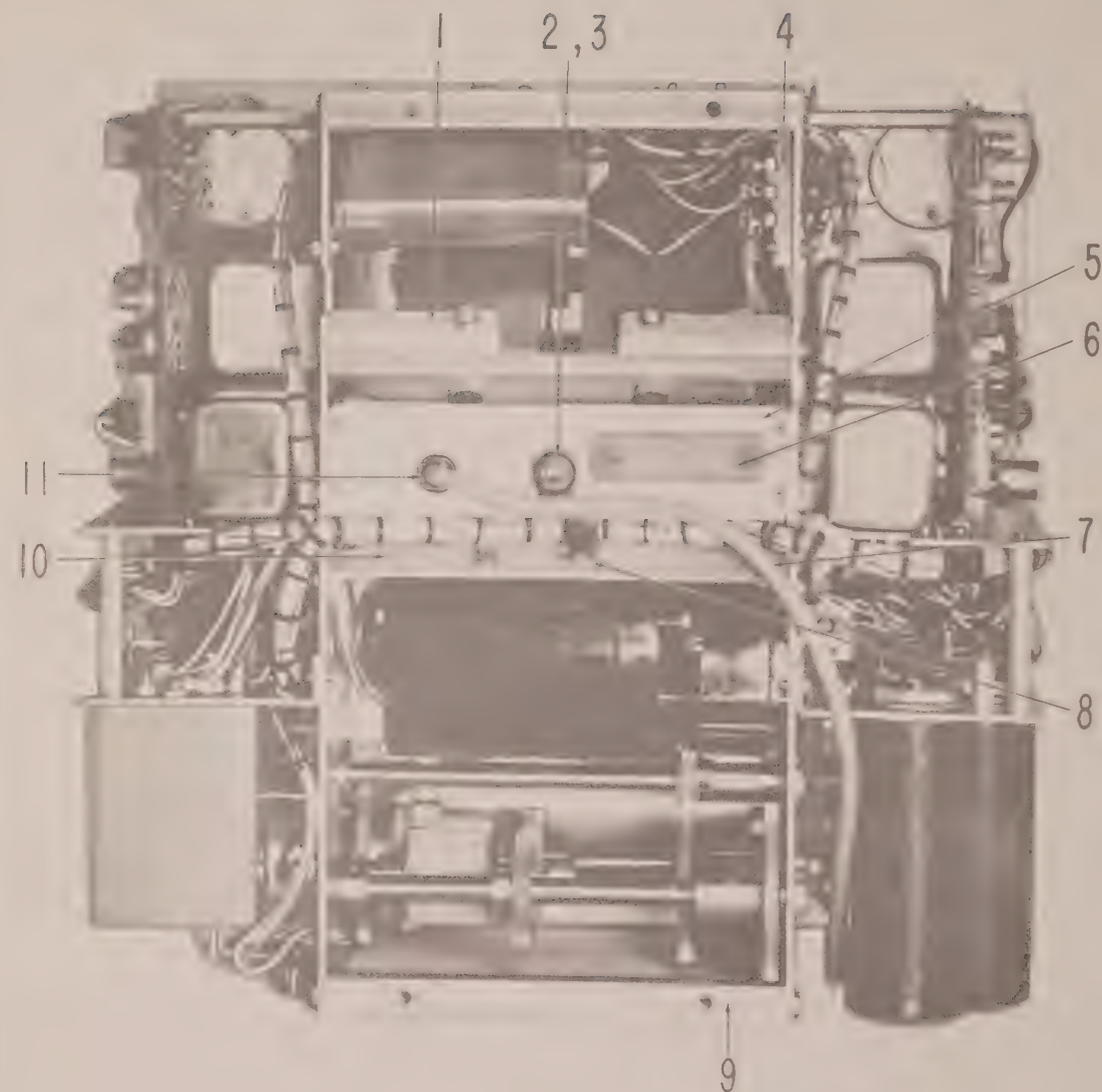


FIGURE 14. RECORDER, MODEL 320, BACK VIEW

REF. NO.	DESCRIPTION	SANBORN NO.
1	Galvy Mounting Plate	320-110
2	Fuse Holder	26H-2MS
3	1 Amp Slow Blow (F1)	26B-5MS
4	3 Contact Terminal Strip (ES)	64B-5
5	4-40 x 3/8 Sems Bracket, Fuse Perm #6 Perm #2 Sems 6-32 x 3/8	83A-4-6B 320-149 40P-6-2 40P-2-2 83A-6-6B
6	Nameplate Sems 2-56 x 3/16	320-102 83A-2-3B
7	Flng and Cord Set	10G3-21MW
8	Cable Clamp	12C-10
9	6-32 x 3/8 Sems	83A-6-6B
10	Side Plate Spacer	320-161
11	Motor Mounting Plate	320-160
	Strain Relief Clamp	12A-26

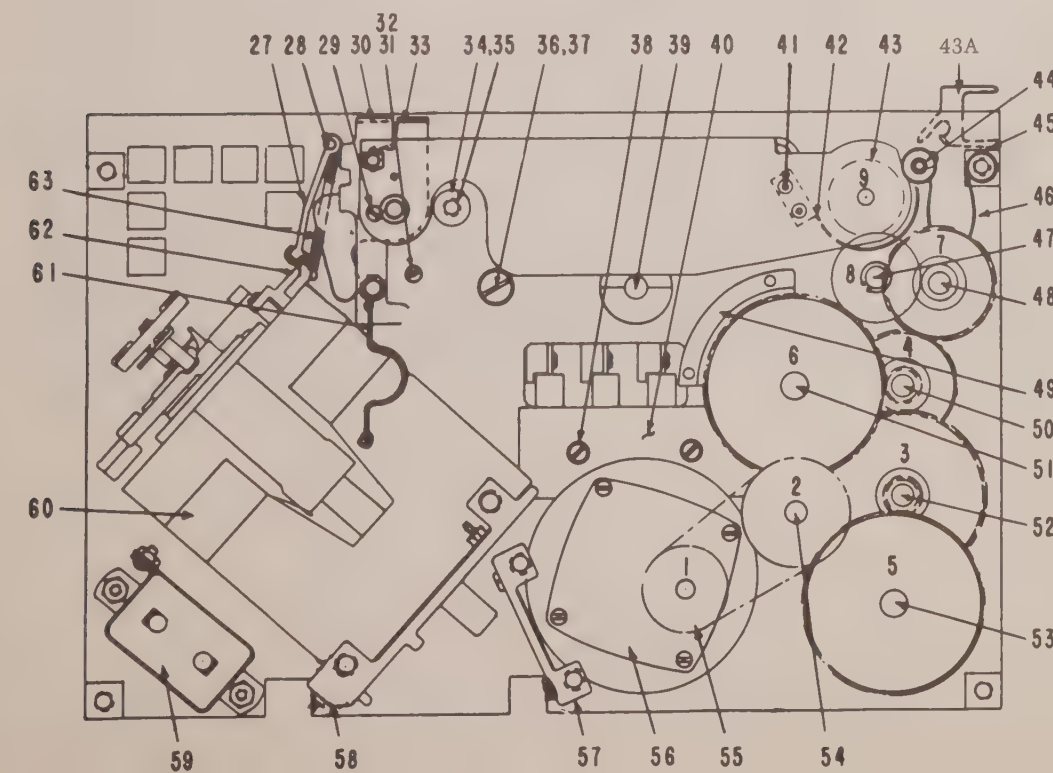


FIGURE 15. RECORDER ASSEMBLY

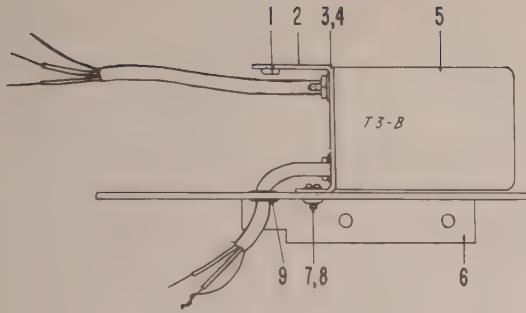


Figure 16. Upper Right Chassis Assembly 320-100-C7

REF. NO.	DESCRIPTION	SANBORN NO.
1	#4 Pm	40P-4-2
2	Bracket, Transformer Mounting	320-169
3	6-32 Lockwasher	73A-6
4	6-32 Hex nut	
5	Transformer, T3B	66B-117MS
6	Chassis, Upper Right side	320-156
7	4-40 X 3/8 Sems	83A-4-6B
8	#4 Pm	40P-4-3
9	Eyelet	20A-22

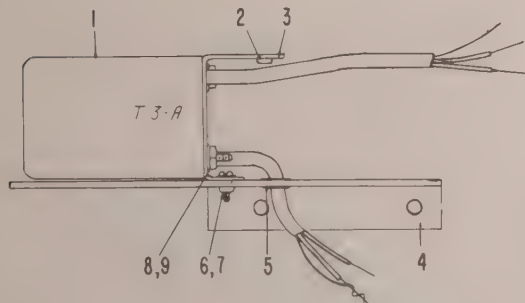
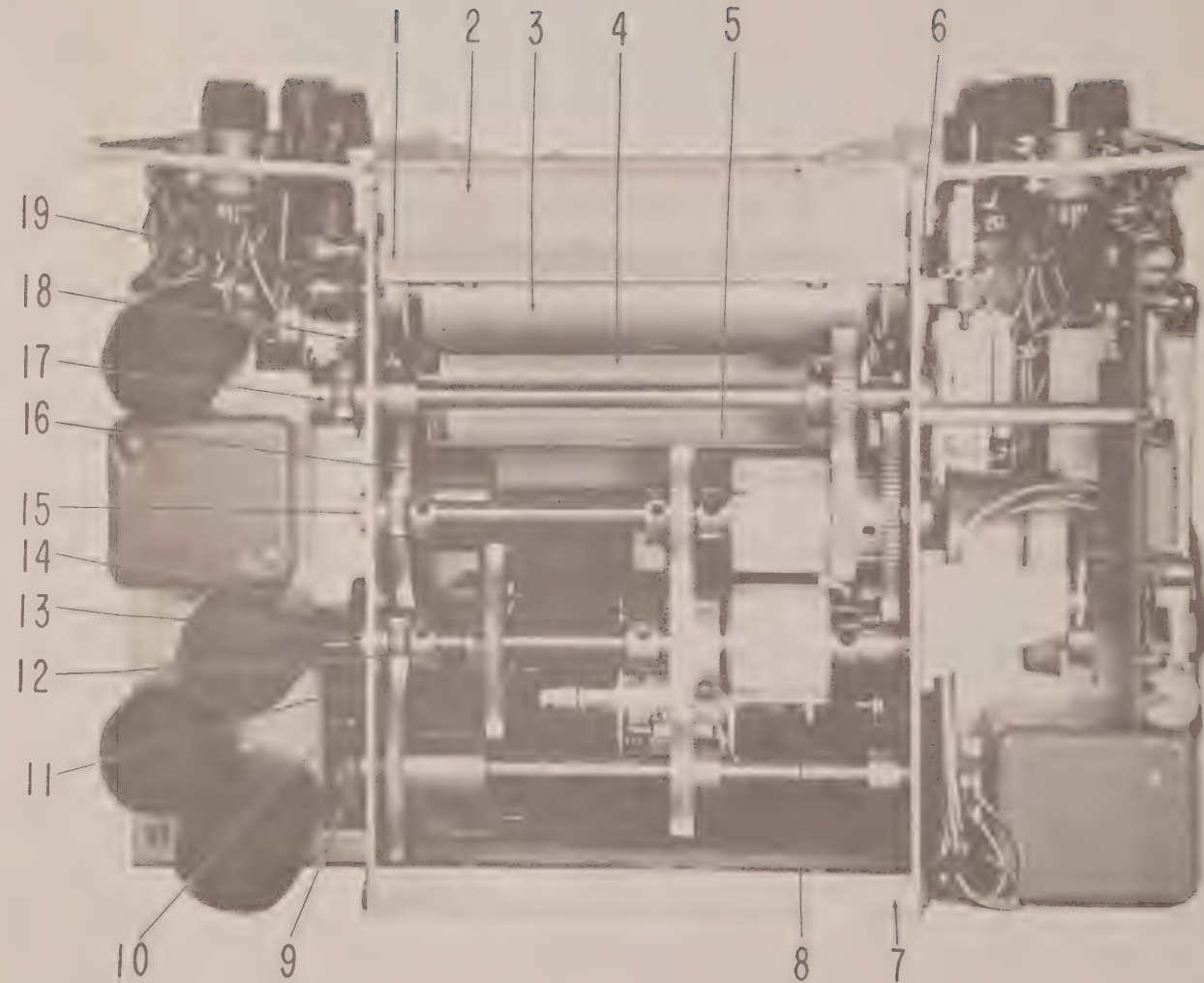


Figure 17. Upper Left Chassis Assembly

REF. NO.	DESCRIPTION	SANBORN NO.
1	Transformer, T3A	66B-117MS
2	#4 Pm	40P-4-2
3	Bracket, Transformer mounting	320-169
4	Chassis, Upper Left side	320-154
5	Eyelet	20A-22
6	4-40 X 3/8 Sems	83A-4-6B
7	#4 Pm	40P-4-3
8	6-32 Lockwasher	73A-6
9	6-32 Hex nut	

Figure 18. Sanborn Dual Channel DC Amplifier - Recorder Model 320, Bottom View

REF. NO.	DESCRIPTION	SANBORN NO.
1	Spacer, side plate	320-162
2	Spacer, square	701-12T6-25
3	Guide, paper drive roll 4-40 X 3/16 Sems	320-114 83A-4-3B
4	Permapaper, Medical	651-42
5	Permapaper, Industrial	651-52
6	Gear Cover	320-165
7	Retainer, drive bearing	320-125
8	Spacer, side plate No. 10 Shoulder screw	320-161 838-7
9	Motor, 50 cycle, 38B-54 - 60 cycle 38B-37 Parts on shafts are called from left to right on figure Shaft No. 5 Spacer	825-24 701-24D375-1
	Gear with hub, 120T-48P S.S.	5G-34
	Overrunning miniclutch	5C-4
	Gear with hub, 72T-48P S.S.	5G-35
	Collar 3/8 I.D.	827-6
	8-32 X 1/8 Lg. Allen hd. cup pt. screw	81A-832A
	Washer, spacing	710A-15
10	Motor sprocket	5S-6
11	Drive chain, steel	5B-3
12	Shaft No. 2 (behind No. 3) Sprocket 25T-3/16 P 8-32 X 1/8 Lg. Allen hd. cup pt. screw Spacer Gear 36T-48P-20° PA	825-21 5S-7 81A-832A 703-16D3-12-29 5G-71 825-22 710A-15
	Washer, spacing	5G-32
	Gear with hub, 24T-48 S.S.	81A-832A
	8-32 X 1/8 Lg. Allen hd cup pt. screw	5G-72
	Gear, 108T-48P 20° PA	81A-832A
	8-32 x 1/8 Lg. Allen hd. cup pt. screw	827-5
	Collar	320-100-C18
	Clutch hub assembly	5G-36
	Gear, 48P-72T	358-700-C12
	Hub assy	358-703
	Hub, spring clutch	358-705
	Sleeve, clutch spring	358-706
	Spring, clutch	358-704
	Adaptor shaft	81A-1032G
	10-32 X 1/4 Allen hd cup pt	703-16D312-14
	Spacer	5S-6
14	Sprocket 8-32 X 1/4 Allen hd. cup pt. set screw	81A-832A 825-23
15	Shaft No. 4 Gear with hub, 24T-48P S.S. 8-32 X 1/8 Lg. Allen hd. cup pt. set screw Gear with hub, 72T-48P Clutch hub assembly Hub assembly Gear, 48P-72T 8-32 X 1/4 Soc. hd. Set screw Parkerized Gear, 96T-40P 20° PA Washer, spacing	5G-32 81A-832A 5G-33 320-100-C19 358-700-C12 5G-36 5G-74 710A-15 825-25
	Shaft No. 6 Gear with hub, 24T-48P S.S. Overrunning Miniclutch Gear, spur 8-32 X 1/8 Lg. Allen hd., cup pt. set screw	5G-34 5C-4 5G-73 81A-832A 825-26
	Gear with hub, 24T-48P S.S. 8-32 X 1/8 Lg. Allen hd., cup pt. set screw Collar 8-32 X 1/8 Lg. Allen hd. cup pt. set screw Gear with hub 72T-48P 20° PA Washer, spacing	5G-32 81A-832A 827-5 81A-832A 5G-33 710A-15 320-124 59A-9
18	Stud shaft Retainer ring, external 5/16 10-32 Hex nut Gear, 60T-48P-20° PA	5G-75 5G-30
19	Gear, 48T-48P-20° PA	



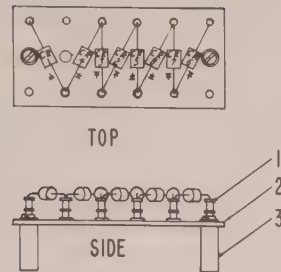


Figure 19. Diode Mounting Board Assembly (E4) 320-100-C2

REF. NO.	DESCRIPTION	SANBORN NO.
1	Turret Lugs	34B-8
2	Terminal Board	750-4P6
3	4-40 X 1/4 Sems	83A-4-4B
4	Spacer	701-8T4-20B
CR1 thru CR8	Rectifier 1N2065	16A-39

FIGURE 20. ACCESSORIES SUPPLIED WITH SANBORN RECORDER, MODEL 320

ITEM	DESCRIPTION	AMT.	SANBORN NO.
1	Permapaper Industrial	1	651-52
1	Permapaper Medical	1	651-42
2	*12 Contact Female Plug	2	10A12-1FW
3	Plug, Miniature Phone	2	10G2-22MW
4	Fuse, 1 Amp. Slow Blow	1	268-SMS
5	Stylus Pressure Tester	1	442
6	Writing Arm	2	398
7	Screwdriver (Stylus Pressure)	1	37A-10A
8	Spline Wrench Assembly	1	100-600-C5
	*Changed to 3 Contact Female	2	10G3-34FW
	1 Wire Adapter	1	10G3-11MEW
	Rubber Bushing	2	77D-5

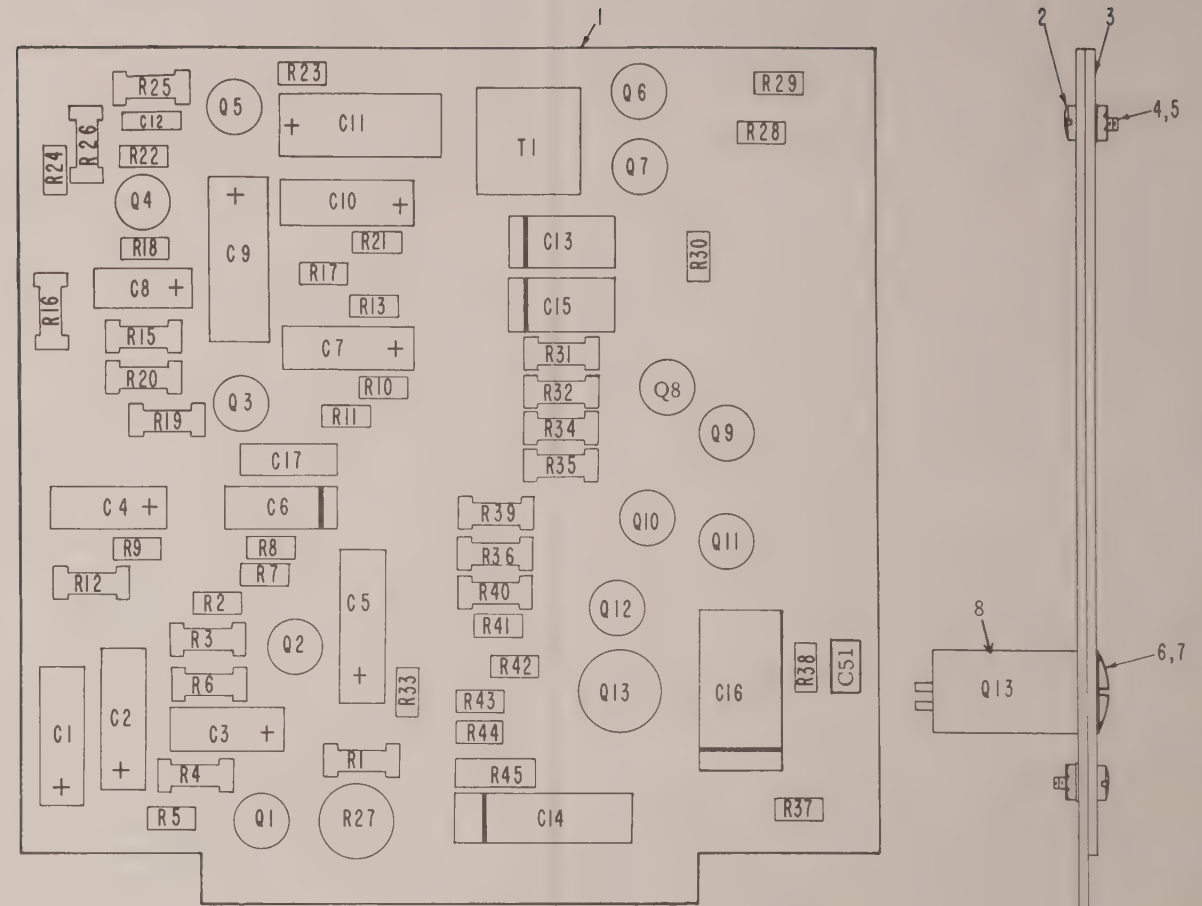
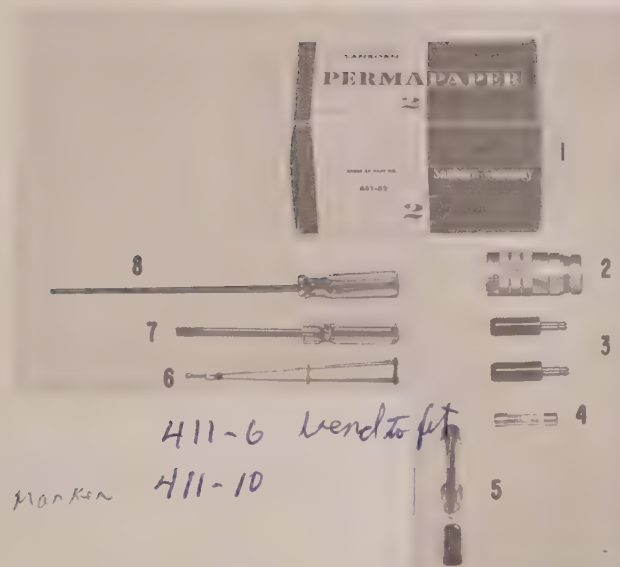
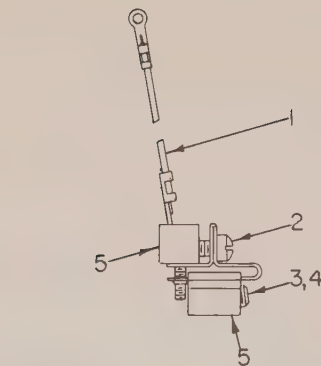
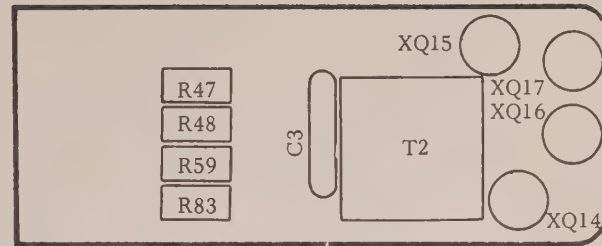
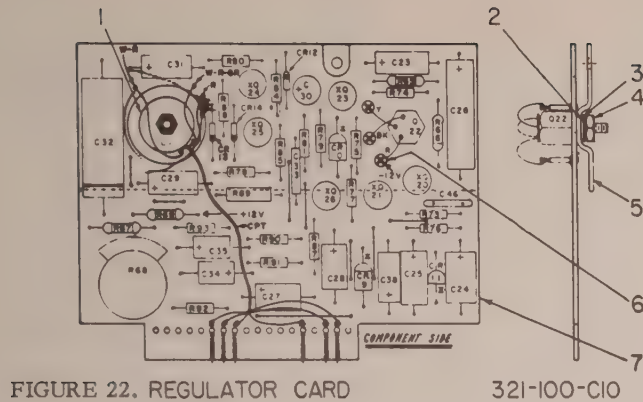


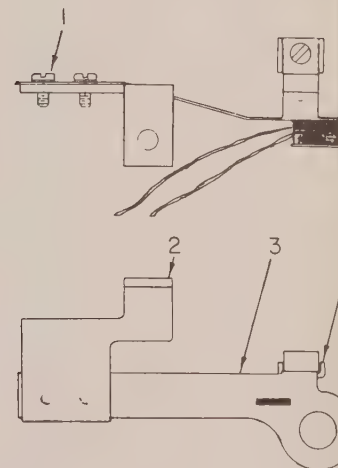
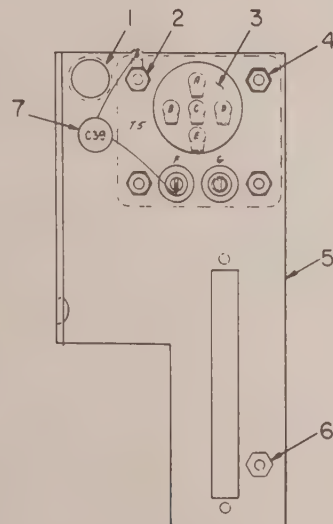
FIGURE 21. MEDIUM GAIN PREAMPLIFIER CARD, 950-3400

REF. NO.	DESCRIPTION	SANBORN NO.
1	Printed Board (machined)	752-89
2	4-40 x 3/8 Screw	80A-440-6B
3	Backing Strip and Shield	950-3400-C3
4	#4 Lockwasher	73A-4
5	#4 Hex Nut	
6	#8 Ext. Lockwasher	72A-8
7	8-32 x 3/16 Screw	80A-832-3B
8	Transistor Heat Sink	16S-4





REF NO.	DESCRIPTION	SANBORN NO.
1	Hex Nut 4-40	74F-122
	Washer, Fiber	73A-6
	Lockwasher #4	80A-440-128
	Screw 4-40 x 3/4" Long	74A-108
2	Washer, Flat	74T-3
3	Lockwasher #10	
4	Hex Nut 10-32	
5	Heat Sink	299-210
6	Turret Lug (Long)	34B-24
7	Printed Board (Machined)	752-143



REF NO.	DESCRIPTION	SANBORN NO.
1	Pigtail Assy.	613-100-C8
2	#4-40 NC-3x 3/16 Lg. Fil. Hd. S.S. Sc.	85B-4-3C
3	#8-32 x 3/16 Lg. Set Screw	81B-832-3B
4	Shoe	606-122
5	Adapter & Spring Assy. Consisting of: Spring Stylus Mtg. Adapter Machine Screw 1/4 x 1/72 Fil. Hd.	613-100-C6 613-110 613-107 85B-172-4C
6	Clamp	613-108

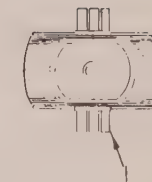


FIGURE 25. LOWER RIGHT CHASSIS ASSEMBLY
320-100-C6

REF NO.	DESCRIPTION	SANBORN NO.
1	Eyelet	20A-30
2	Lug, Right Angle	34A-5A
	Hex Nut 6-32	73A-6
	Lockwasher 6-32	66B-115MS
3	Transformer	701-876-72
4	Spacer	320-157
5	Chassis, Lower Right Side	83A-6-68
6	3/8" 6-32 Sema	701-876-72
	Spacer	8E-6
7	Capacitor .01 MPD Disk	

FIGURE 26. COIL AND STYLUS HOLDER ASSEMBLY 608D-100-C3

REF NO.	DESCRIPTION	SANBORN NO.
1	#2-56 Sem x 3/16 Long	83A-2-3B
2	Bracket, Coil Holder	608-107
3	Coil Assembly Consisting of: Black Wire x 5" Long Lead Marker Coil Assembly Consisting of: 1200 Turns #44 Wire Bobbin Holder, Coil & Stylus	608D-100-C4 W1CJ-32-1 821-300-C3 20P-1 608-101-P1
4	Shoe, Clamp	158-1022
5	Clamp, Lead Marker	158-1023
6	#2-56 Sem x 3/16 Long	83A-2-3B

FIGURE 27. GALVANOMETER COIL ASSEMBLY
606-100-C2

REF NO.	DESCRIPTION	SANBORN NO.
1	Ass'y Galvy Coil Term, Insulation	51-1505
2	Pivot, Coil	606-114
3	Frame, Galvy Coil	600-101
4	Bracket, Coil (Lower)	606-115

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